Estimating Selected Disease and Non-Battle Injury Echelon I and Echelon II Outpatient Visits of U.S. Soldiers and Marines in an Operational Setting from Corresponding Echelon III (Hospitalizations) Admissions in the Same Theater of Operation

Master of Science in Public Health Thesis

By

Dennis B. Kilian

Uniformed Services University of the Health Sciences

Graduate School of Medicine

APPROVED:

Arthur P. Lee 19 June 2000

Arthur Lee, Lieutenant Colonel, USA, Ph.D., PE, Committee Chair

27 Jun 00

Larry Lynch, Lieutenant Colonel, USA, MS, Member

19 Jun 00

Joseph Laundree, Major, USA, MSSI, Member

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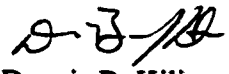

Dennis B. Kilian
Captain, U.S. Army
Department of Preventive Medicine and Biometrics

ABSTRACT

Non-hospitalized morbidity amongst deployed military forces can have adverse affects on military operations. This has been demonstrated throughout history from Napoleon's typhus outbreak in the retreat from Moscow, to Merrill's Marauders' dysentery outbreak in Burma, and to the US Forces - Somalia dengue and malaria outbreak. Military medical planners do not have references to estimate the amount of Disease and Non-Battle Injury (DNBI) "walking wounded." These walking wounded troops are personnel who have some level of morbidity, making them have less than an optimum level of health. This decrement in their optimum level of health may impact on their individual and collective ability to accomplish their military mission. These troops are not hospital admissions; rather, they receive health care from an Echelon I or II health care facility, if at all.

Currently, DNBI estimate systems focus on hospital logs and not battalion aid stations or medical company patient logs. As a result, the vast majority of morbidity within military units is either overlooked or not estimated. Within the Theater of Operations, military hospitalization data by diagnosis category is normally available. If the corresponding outpatient morbidity in the force could be estimated from this data, the commander could better assess the health of the command and the mission readiness of the force. A tool for estimating these unreported DNBI cases is presented in this thesis.

The data used in this analysis was gathered by the 227th Medical Detachment (Epidemiology) under the command of MAJ Jeff Gunzenhauser in Somalia from January

to March 1993. This database contains both hospital admission data and outpatient visit data at Level I and Level II facilities for both the U.S. Marine Corps and the U.S. Army units in the Area of Operation. The limitations of the data and the model are a relatively short timeframe of data collection, an environmentally harsh environment with no remaining infrastructure, and a high infectious disease threat. For these reasons, this model can be used only as an estimation tool. Mission and geographical location information should be considered when using this model, along with FM 8-55, Planning for Health Service Support, dated 1994; FM 101-10-1/2, Organizational, Technical and Logistical Data Planning Figures, dated 1987; and other medical planning publications.

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Dennis B. Kilian
Captain, U.S. Army

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I would like to also thank LTC (P) Jeff Gunzenhauser and the soldiers of the 227th Medical Detachment, who traveled all the miles in Somalia in 1993 to collect the database that was used in this thesis. Without them, this work would not have been possible for the Somalia Theater of Operation.

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I would be remiss if I did not mention two behind the scenes professionals who greatly enhanced my two years spent in the MSPH program; John Resta, P.E., Chief,

Deployable Environmental Surveillance Program, United States Army Center for Health Promotion and Preventive Medicine, and Jack Heller, Ph.D., Senior Scientist, Deployable Environmental Surveillance Program, United States Army Center for Health Promotion and Preventive Medicine Their contributions in global information systems; air, water and soil sampling; exposure and risk assessments; water and waste water engineering, and environmental modeling to this degree program have made this time very enjoyable and educational.

Most importantly, I want to thank my wife, Lori. Your support and superior editing skills are greatly appreciated. Thank you.

DEDICATION

To my grandparents, Marvin and Mae Biggs, who raised me; I lost both of them this year while in school. It is their love, sacrifices, support, and their teaching of the skills of life that have enabled me to become the person I am today.

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CHAPTER ONE

Background

"I've been to a lot of war zones and famine camps and cholera camps, but I've never, ever seen anything like Somalia was at that time. I've often compared it to a *Mad Max* film. You've got people driving around in technical cars with machine guns. There's no government infrastructure, no law and order."

- Khalil Dale, Red Cross

Somalia. For the United States it began 4 December 1992, as a humanitarian operation to provide security to international relief operations, when 25,000 U.S. troops were ordered into Somalia. For most Americans, it is most vividly remembered for what happened on 3-4 October 1993; the scene of the worst firefight that US troops have experienced since Viet Nam, resulting in 18 dead and 84 wounded troops. [1] Demonstrated in this thesis, with data from the Somalia experience, is the first comprehensive military healthcare database that captures both outpatient visits and hospital (Echelon III) admissions within a single theater of operations.

Much can be learned by medical planners from the US involvement in Somalia. While there, US troops were exposed to a multitude of diseases and vectors of disease coupled with varying military operational intensities[2] ("Twenty-four hours a day [U.S.] soldiers lived with the threat of being shot at, having a hand grenade thrown at them or receiving indirect fire attacks.").[3] In addition to this threat was the total lack of any remaining infrastructure in country. Sanitation, water, sewer, electricity, postal services, roads, and other civil works were ransacked by looters for anything of value or were in such bad shape they had simply been abandoned. Medical support for indigenous persons was almost exclusively provided by Non-Governmental Organizations, such as

"Doctors without Borders" or "Red Cross / Red Crescent." The primary airhead in Somalia was the remnants of Mogadishu International Airport. The nearest airhead where utilities such as electricity, fuel, piped water, etc., were readily available to U.S. Force Somalia was located in Mombasa, Kenya, located to the southwest. There also was an airport located in the southern part of the Theater of Operations in Kismaayo (also spelled Chisimayu, see Figure 1), Somalia. This airfield did receive C-5A sorties that supported the US Forces in the Jubba River Valley, located in the lower third of the country (see Figure 2), but had no utilities.[4] Most malaria and dengue fever cases experienced by U.S. Forces Somalia were suffered by troops from this region.[5]

Figure 1. Political Map of the Horn of Africa.[6]

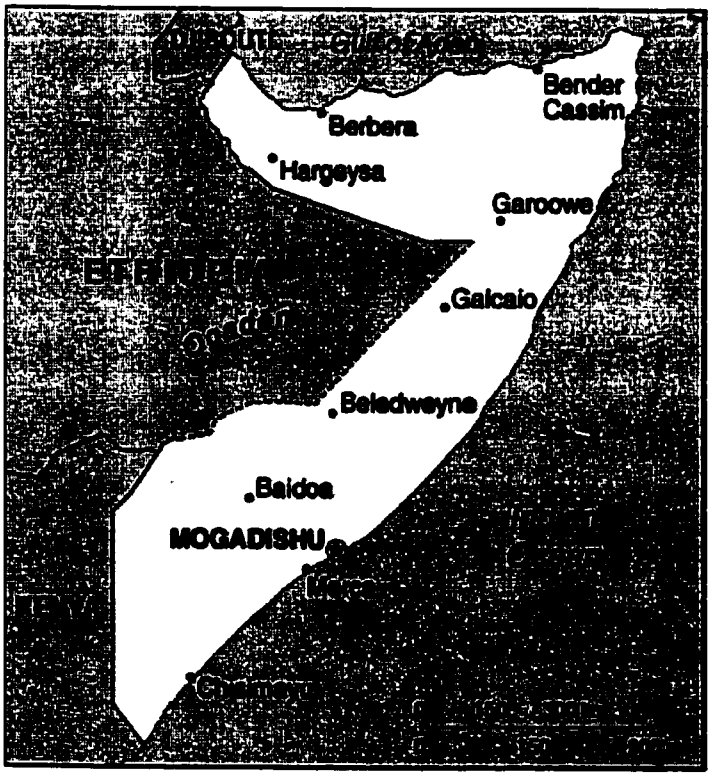
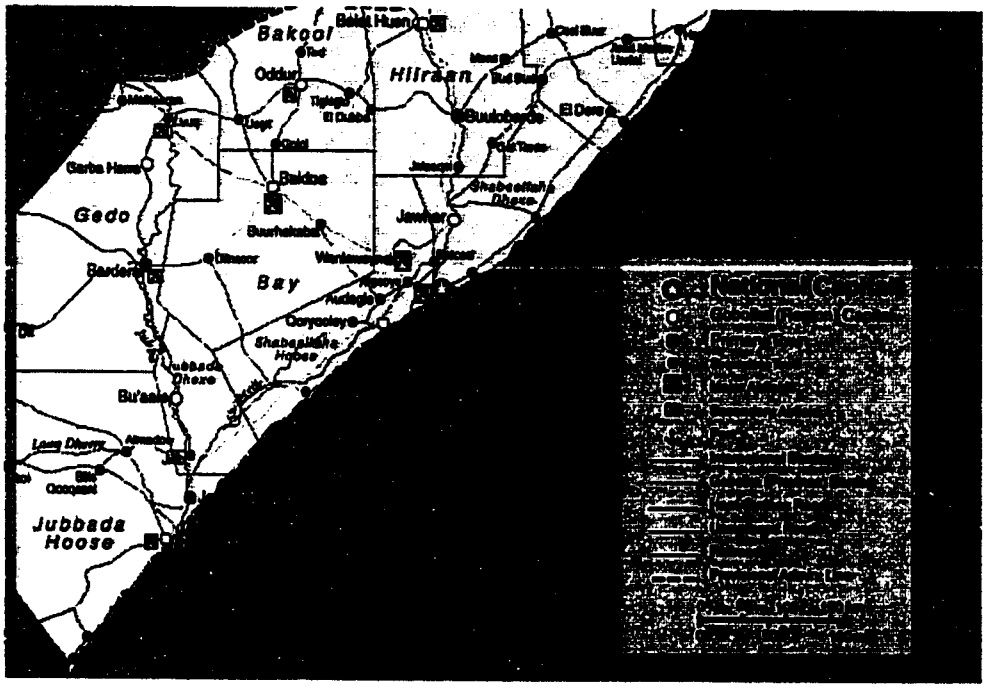


Figure 2. U.S. Forces Area of Operations in Somalia during Operation Restore Hope.[7]



This was a Combined Task Force, with many different nations from around the globe providing troops to this humanitarian endeavor. A medical threat concern with a Combined Task Force is that troops bring disease with them. The diseases that they bring may or may not be endemic to the Theater of Operations, and as such may present an overlooked threat by planning cell personnel back at the deploying units home station prior to deployment. Even if a disease of concern is endemic to the Theater of Operations, many Americans have an assumption that deploying troops from the various countries are healthy. This potentially faulty assumption can result in direct exposure to a disease of concern that comes from troops from other countries working with US

Forces. An example is English soldiers infecting Indian tribes in North America during the French and Indian Wars with the disease, smallpox.[8]

The estimating tool within this thesis is meant to aid commanders and medical planners estimate the amount of DNBI "walking wounded," by type, that they have in their units based upon hospital admissions of similar type. This should assists commanders and planners in more accurately ascertaining the morbidity within a given command, thus better describing the "fit to fight" population. This thesis is based upon data collected from January through March 1993 by the U.S. Army's 227th Medical Detachment (Ft. Lewis, WA) during its deployment for Operation Restore Hope.[9]

There are several terms that come from various fields that will be used throughout this thesis. These terms are defined in the glossary of terms, located at the end of this document.

CHAPTER TWO

Understanding the Problem

"Go, sir, gallop, and don't forget that the world was made in six days. You can ask me for anything you like, except time."
Napoleon Bonaparte

Time on the battlefield is a precious commodity and time lost by service members to DNBI can change the outcome of a battle. For centuries, DNBI has been recognized as a major form of morbidity and mortality impacting combat effectiveness of military units.[10,11] Examples include operations as recent as U.S. Forces Somalia's malaria and dengue fever experience to Rommel's Afrika Corps' hepatitis blunder in World War II to Napoleon losing ninety percent of his soldiers to cold and typhus during his march to and from Moscow.[12] Morbidity and mortality suffered by soldiers caused by DNBI in not new.[13] However, even though DNBI have impacted soldiers for all of time, our ability to quickly estimate and track DNBI at the brigade level and lower or in units geographically separated has been limited. Historically, we rely on hospital admission logs to determine medical readiness issues and then typically, know very little about the "walking wounded" or the soldier who was sick but not sick enough to be hospitalized.

Most historical data of morbidity and mortality estimates, found in FM 8-55, Planning for Health Service Support dated 1994, or FM 101-10-1/2, Organizational, Technical and Logistical Data Planning Figures dated 1987 are neither joint nor combined data. Rather, the data is empirical in nature from an era when U.S. Forces fought primarily service specific fights and alone. These two primary documents, along

with a host of other references, are used by medical planners in conducting a Medical Intelligence Preparation of the Battlefield, also known as MIPB. During the MIPB process, a sub-component of the Intelligence Preparation of the Battlefield process (IPB), staff planers estimate several types of casualties based upon the various Course of Action (COA) plans derived from the Commander's Intent and the threat from enemy actions and the environment. It is from the COA selected by the Commander that the medical force mix, or the type and number of units needed to support the chosen COA is determined.[14]

Another tool that medical planners can use is the Defense Medical Epidemiology Database (DMED) application that is operated by the Defense Medical Surveillance System (DMSS). DMSS is a system that the Assistant Secretary of Defense for Health Affairs (ASD-HA) directed the Army to establish in March of 1997. DMSS is an executive information system database for medical surveillance decision support. It operates in the Corporate Executive Information System or CEIS business area of the Military Health System (MHS). DMSS receives and integrates data from various DOD sources worldwide.[15],[16] The data is of highly varying quality, because DMSS does not actively survey for information; it waits until data is passively forwarded. Also, the focus of DMED is on fixed facility health care systems and does not contain deployment data from field medical units. As a result, it does not provide tactical commanders, the regional combatant CINCs (CENTCOM, EUCOM, PACOM, or SOUTHCOM), or the National Command Authority a tool in decision making concerning deployed U.S. Forces. The Internet link for DMED is http://amsa.army.mil.[17]

The United States Army Medical Department Center and School's (AMEDDC&S) Directorate of Combat Doctrine Development (DCDD) produced a DNBI calculator, which is no longer used. The weaknesses of the calculator were it did not weigh the importance of the various threats, it looked at only a handful of countries, and it did not consider the infrastructure of the country of concern.[18]

There are many reasons why this study can be important to the Department of Defense (DoD). One is the DoD now fights as a joint force; previous references were developed in a uniservice environment. Another is US military needs a tool that can quickly estimate morbidity in its forces in the context of today's environment. This is partially because of the leveraging of technology over personnel in the U.S. military. To illustrate this, consider that in 1991 a U.S. armor battalion consisted of 58 M1 tanks. Today, the same battalion is composed of 42 M1 tanks and is required to control more area. As a result, the loss of a single tank due to DNBI can result in a larger area left uncovered by the same battalion than 10 years ago. Additionally, with an expanded role for the United Nations Security Council, the US DoD will seek to support a Combined effort in future operations. Examples of this have been seen in Bosnia, Kosovo, and East Timor. This data is from such a Joint and Combined experience and lends itself to the construction of a tool to be used by force planners to forecast DNBI in a monsoonal, war torn, third world country.

CHAPTER THREE

Methodology

"War is the realm of chance. No other human activity gives it greater scope; no other has such incessant and varied dealings with this intruder. Chance makes everything more uncertain and interferes with the whole course of events."

Karl Von Clausewitz

Research Design

This descriptive study analyzes the utilization of United States deployed medical facilities by US military service members, including both outpatient visits and hospitalizations in Somalia during the early phases of force deployment of Operation Restore Hope from January 1993 to March 1993. It is an observational study of historic data, reporting a measure of central tendency (the mean) by diagnosis and weekly intervals for the proportion of specific diagnoses that are hospitalized.

Sample

This data set covers the first nine weeks of data between Echelons I and II and Echelon III healthcare. Week one of the data set is the week ending 16 January 1993 and week nine is the week ending 13 March 1993. The subsequent weeks to week one end on 23 January, 30 January, 6 February, 13 February, 20 February, 27 February, 6 March and 13 March. During this time frame, there were a total of 12,221 (7,500 Army and 4,721 Navy/USMC) outpatient visits at either Echelon I or Echelon II and 687 (418 Army and 269 Navy/USMC) Echelon III hospital admissions to the 86th CSH. This time frame of 16 January to 13 March corresponds to 115,744 person/weeks of data collection.

Instrumentation

A standard data collection instrument (form) was used throughout the time that the 227th Medical Detachment (Epidemiology) collected outpatient morbidity data from the various Echelon I and II Medical Treatment Facilities, also known as MTFs. Additionally, the 86th CSH operated an Echelon II outpatient clinic for sick call purposes for units operating on the Mogadishu International Airport that did not have organic medical support. While the actual person within the respective MTFs completing the form varied from location to location, the personnel of the 227th periodically reviewed logbooks to ensure completeness and accuracy of transcribed information. Additionally, the 227th personnel used a supplemental form to compile all visits into fourteen diagnostic categories on a weekly basis for their original analysis.[19]

For the 227th database, information on in-patient (hospitalization) morbidity was derived solely from data collected from the 86th CSH Patient Administration Division (PAD) admission logs. All diagnoses were categorized into one of fourteen conditions used in the outpatient surveillance system.[20]

Data Collection

The data set comes from the work of the U.S. Army's 227th Medical Detachment (Epidemiology), based at Fort Lewis, WA. While in Somalia, the 227th was stationed in Mogadishu, near the US Embassy compound. From the Headquarters in Mogadishu, the unit's personnel would go to the various units' supporting medical element and collect the data. This includes Battalion Aid Stations (BAS), Forward Support Battalions (FSB),

Main Support Battalions (MSB), Force Service Support Groups (FSSG), Area Support Medical Companies (ASMC), and the Combat Support Hospital (CSH).[21]

The personnel in the 227th worked closely with the various patient administration personnel to minimize misclassifications of disease category. Additionally, care was taken not to miss or double count patients. For example, a patient who presented with diarrhea on Day 1 and had a follow-up appointment on Day 3 would only be counted as a single visit. However, if a patient presented with diarrhea on Day 1 and subsequently showed up the next day with a broken wrist because of playing volleyball, then they would be counted as two distinct visits. Every effort was made in the patient-regulating arena to ensure that for a patient to be a hospital admission, they had to be seen or referred to the CSH from their supporting Echelon I or II health care organization. This includes the ad hoc Echelon II facility that the 86th CSH operated at the Mogadishu Airport to support several units that were also co-located at the Airport that did not have organic medical support.[22]

A descriptive list of the categories by medical diagnosis is provided in Appendix A. It describes the categories by medical diagnosis or groupings that the preventive medicine physicians had created for this data. This appendix was distributed to the various BAS, FSB, FSSG, MSB and other medical companies or entities that were providing healthcare in the Theater of Operations to standardize patient groupings for epidemiological work. It is from these categories that the 227th Medical Detachment calculated weekly incidence rates of the various outpatient morbidities in theater.

Treatment of Data

While there is outpatient data earlier than 10 January 1993, this date was selected as the study start date to create a synchronous timeline between outpatient visit reports (done on a weekly basis) and the hospital logs (done on a daily basis). The process of synchronizing caused the deletion of two days or six admissions of data from the 86th CSH, since the first day of hospital admissions was 8 January 1993. The data input for both the outpatient visits and hospital admissions both end on 13 March 1993, as the 227th began its preparation for retrograde operations back to Fort Lewis, WA from Mogadishu, Somalia.

LTC (P) Gunzenhauzer provided the database for this thesis in a Microsoft® Excel '97 spreadsheet. Using the "Filter" option in the "Data" function, the first procedure conducted on the database was to filter out all non-US military hospital admissions. (The data logs for the Echelon I and II outpatient visits were already restricted to US active duty military). This procedure was need because the 86th CSH admission logs had entries from U.S. civilians and foreign civilians and military. The next data management operation again used the "Filter" option in the "Data" function to remove all US Air Force hospital admissions (fifteen total) and US Navy hospital admissions that originated from shipboard injuries (two total). Most US Air Force personnel rotated out of Somalia to Kenya on a weekly basis and aircrews even more rapidly, thus greatly reducing the threat experienced by this group. US Navy shipboard personnel live in a very controlled environment with moderate temperatures and practically no disease vector threats. This restricted the study to Joint Task Force

personnel who served ashore in the US Army, US Marine Corps, and US Navy as the subjects in this study. Specifically, it left for analysis, those personnel who had similar or homogenous exposures with regards to the hostile environment experienced by troops in Somalia.

Statistical analysis of the data to attain the descriptive statistics was performed using the "Data Analysis" option in the "Tools" function of Microsoft® Excel '97. SPSS 9.0 for Windows was also used to verify Excel values. A t-distribution was used to compute the 95 % Confidence Interval (CI) as there are nine sample weeks and thereby not a large enough sample to adhere to the central limit theorem and a z-distribution. The formula for a CI is described below as Equation 1.

Equation 1. estimator ± (reliability coefficient) × (standard error)

Our estimator is the nine week mean for each respective category; the reliability coefficient for all categories comes from the t-distribution with eight degrees of freedom and is equal to 2.3060; and the standard error comes from each respective category. The resulting numbers from this calculation are the CI for the respective categories.[23]

Once our estimator is determined, its value is placed into the denominator of Equation 2, listed below. The Echelon III admissions data would come from collected medical surveillance data from the supporting hospital. This allows for the calculation of predicted DNBI at Echelon I and II by specified type.

Equation 2. $\frac{\text{Echelon III admissions}}{\text{Estimation Proportion Value by Type}}$ = Predicted DNBI Echelon I & II OPV

A demonstration of how to use the tool proposed by the results of this analysis is found in Appendix D. It illustrates how to estimate DNBI experienced at Echelon I and II for a given force, given the corresponding Echelon III admission data.

Finally, the character of the US medical mission in Somalia at the time of this data collection is noteworthy. The initial medical mission was to deploy Army medical units to support the deploying force and provide treatment to combat casualties and routine DNBI to US Forces Somalia.[24] This fact is not meant to prejudice any reader; it is meant to remind the reader that the US Military at the time of US involvement in Somalia still held the Weinberger Doctrine[25] as truth. The Weinberger Doctrine refers to a speech that became a cornerstone to U.S. policy. The Honorable Caspar W. Weinberger, who was then the Secretary of Defense, delivered it to the National Press Club on 28 November 1984. The Weinberger Doctrine is composed of six principals. The first is the United States should not commit forces to combat overseas unless the particular engagement or occasion is deemed vital to our national interest or that of our allies. Second is if the United States decides it is necessary to put combat troops into a given situation, we should do so wholeheartedly, and with the clear intention of winning. Third, if the United States does decide to commit forces to combat overseas, it should have clearly defined political and military objectives. The fourth principal is the relationship between our objectives and the forces committed (size, composition, and disposition) must be continually reassessed and adjusted if necessary. Fifth principal,

before the U.S. commits combat forces abroad, there must be some reasonable assurance we will have the support of the American people and their elected representatives in Congress. The sixth and last principle, the commitment of U.S. forces to combat should be a last resort.[26] The US DoD had fought and won decisively the Persian Gulf War just two years before and had seen the Berlin Wall fall just four years previous using this Doctrine as well as fighting and wining two additional conflicts; Granada and Panama. Since the Persian Gulf War, specifically starting with Somalia, US military forces have been deployed around the world in ways not consistent with the Weinberger Doctrine. As a result, DNBI rates will be different from projections in FM 8-55 or FM 101-10-1/2, since the U.S. DoD is utilized differently today than in the past.

CHAPTER FOUR

Results

"There is no approved solution for any tactical situation."

-GEN George S. Patton

Of the fourteen original diagnostic categories, five were selected for analysis, plus the *total* column. Collectively, diarrheal, dermatological, respiratory, orthopedics/injuries and the unexplained fevers had the greatest impact from the fourteen diagnostic categories on the deployed force in both outpatient visits (Figure 3) and hospitalizations (Figure 4).

The *total* column, a compilation of all 14 diagnostic categories, does include data from the nine categories not specifically analyzed by this thesis to provide health planners a crude measure of non-specific morbidity within the force. The values given in Table 1 are reflective of weekly proportions of hospitalizations divided by outpatient visits, by diagnostic category. The values given at the bottom of Table 1 are the average proportions for the 9-week period for each specific diagnosis category. The summary mean values (the total number of admissions for each category divided by the total outpatient visits during the 9 week period) for diarrheal, dermatological, respiratory, orthopedic/injury, unexplained fevers and total morbidity values are 0.064, 0.010, 0.030, 0.052, 0.798, and 0.056, respectively.

Table 2, listed below, contains the descriptive statistics for the six columns (Diarrhea/GI, Dermatological, Respiratory, Ortho/Injury, Unexplained Fever, and Total Morbidity) that were analyzed.

Based upon this analysis, the following comments can be made. Proportionate morbidity of hospitalizations to outpatient visits can be estimated at the 95% confidence level for most diagnostic categories. Specifically, the 95% confidence interval ($p<0.05$) for each of the categories was diarrheal (0.027, 0.087), dermatological (0.004, 0.018), respiratory (0.011, 0.057), orthopedic/injury (0.041, 0.065) and total morbidity values (0.047, 0.071). The unexplained fever diagnostic category could not be estimated at a 95% confidence level. Upon discussing this finding with professionals familiar with Operation Restore Hope[27], they theorized that personnel presenting symptomatic for the unexplained fever diagnostic category were immediately evacuated to the 86th CSH. It was at the 86th CSH, where appropriate diagnostics were available to determine if patients in this category had dengue fever or malaria.[28] This evacuation procedure was due to the extreme concern for malaria and dengue fever after the outbreak of these two diseases in a U.S. Marine Regiment located in the Jubba River Valley during Operation Restore Hope. In evacuating personnel in this manner, normal reporting and accounting procedures were circumvented, allowing for miscounting of OPVs for this disease category.

Figure 3. Outpatient Visits of Fourteen Disease Surveillance Categories for U.S. Army, Navy, and Marines Assigned Ashore During Operation Restore Hope, 10 January 1993 - 16 March 1993 (n=12,221).

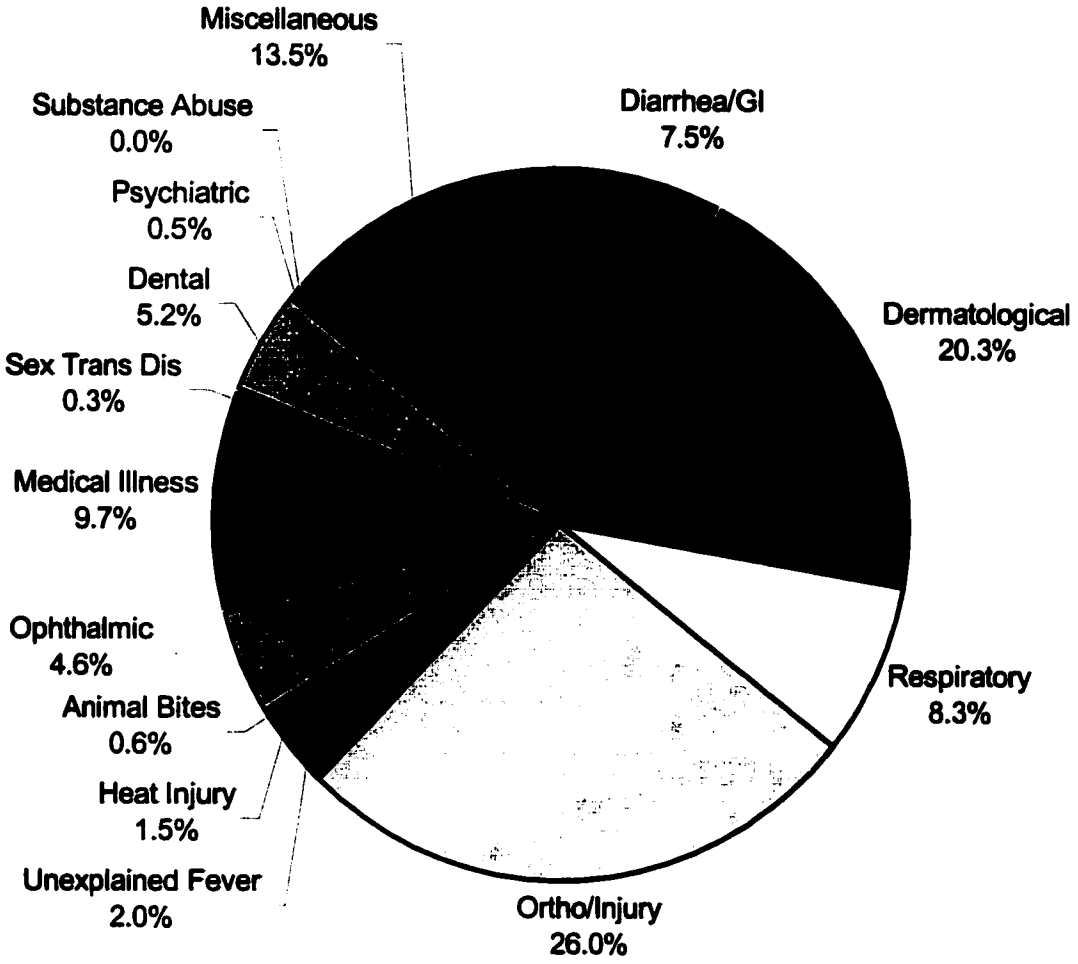


Figure 4. Hospital Admissions (Echelon III) for Fourteen Disease Surveillance Categories for U.S. Army, Navy, and Marines Assigned Ashore During Operation Restore Hope, 10 January 1993 - 16 March 1993 (n=687).

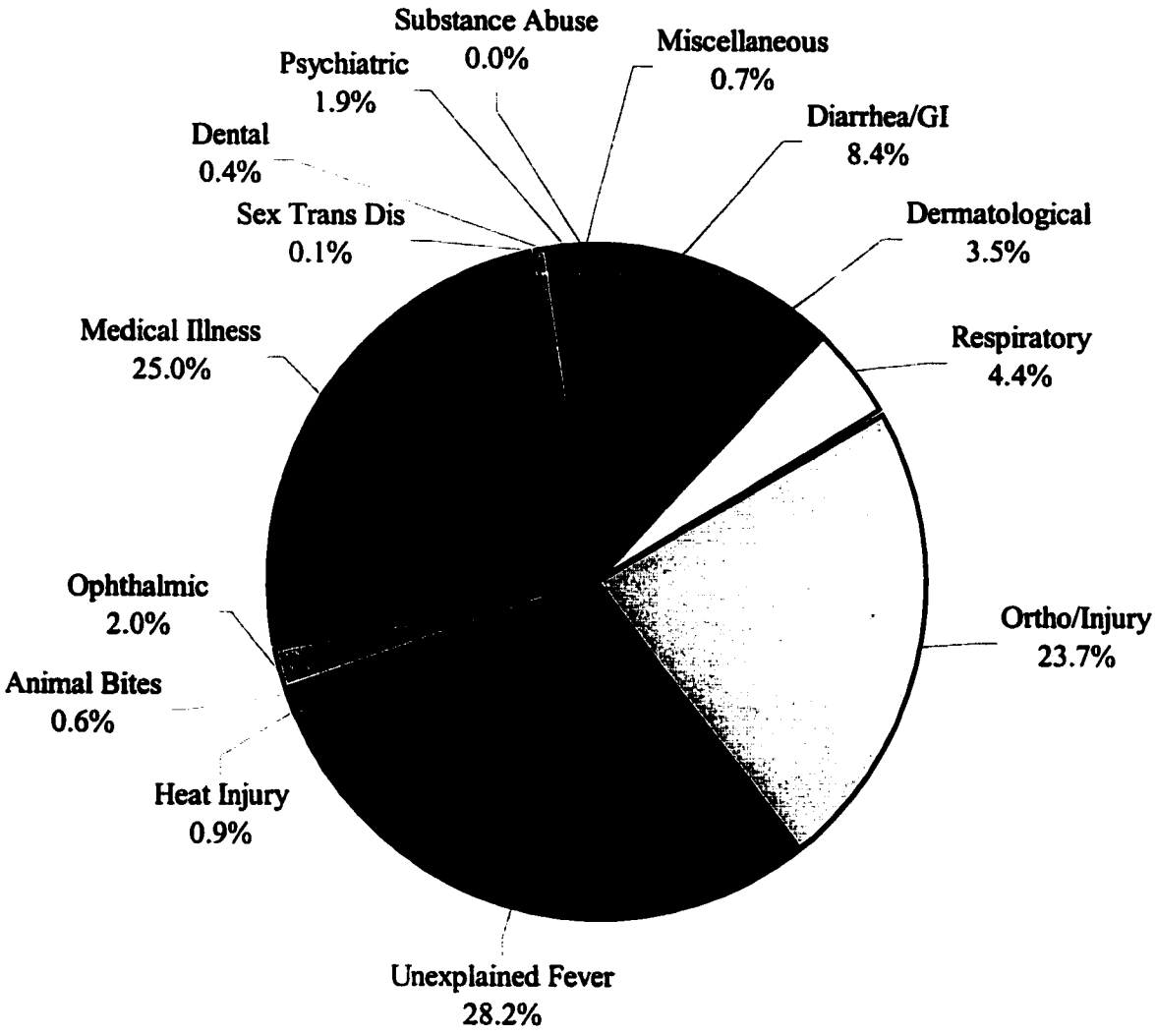


Table 1. Proportion Values by Week for Force Total of Echelon III Admissions / Outpatient Visits at Echelon I and II for U.S. Army, Navy and Marine Forces Ashore During Operation Restore Hope, beginning 10 January 1993.

Week	Diarrhea	Dermatologic	Respiratory	Orthopedic / Injury	Unexplained Fever	Total Morbidity Values
One	0.018	0.000	0.013	0.028	0.119	0.025
Two	0.090	0.002	0.021	0.039	0.816	0.052
Three	0.111	0.014	0.052	0.054	1.321	0.070
Four	0.112	0.022	0.046	0.048	0.684	0.060
Five	0.008	0.004	0.008	0.059	1.333	0.048
Six	0.078	0.009	0.011	0.071	2.500	0.060
Seven	0.033	0.022	0.070	0.051	0.846	0.069
Eight	0.032	0.023	0.088	0.057	1.111	0.080
Nine	0.033	0.006	0.000	0.073	1.583	0.070
9 Week Mean	0.057	0.011	0.034	0.053	1.146	0.059

Table 2. Statistical Analysis of the Nine Weekly Proportion Values for Force Total of Echelon III Admissions / Outpatient Visits at Echelon I and II for U.S. Army, Navy and Marine Forces Ashore During Operation Restore Hope, beginning 10 January 1993.

	Diarrhea	Dermatolgic	Respiratory	Orthopedic / Injury	Unexplained Fever	Total Morbidity Values
Mean	0.057	0.011	0.034	0.053	1.146	0.059
Standard Error	0.013	0.003	0.010	0.005	0.222	0.005
Median	0.033	0.009	0.021	0.054	1.111	0.060
Standard Deviation	0.040	0.009	0.031	0.014	0.667	0.016
Range	0.104	0.023	0.088	0.045	2.381	0.055
Minimum	0.008	0.000	0.000	0.028	0.119	0.025
Maximum	0.112	0.023	0.088	0.073	2.500	0.080
95% Conf. Interval	0.027, 0.087	0.004, 0.018	0.011, 0.057	0.041, 0.065	0.634, 1.658	0.047, 0.071
p-value	0.031	0.007	0.024	0.011	0.513	0.012

CHAPTER FIVE

Conclusions

"Nothing remains static in war or military weapons, and it is consequently often dangerous to rely on courses suggested by apparent similarities in the past."
- Admiral E.J. King

The findings of this thesis support the ability to estimate selected DNBI Echelon I and II outpatient visits of U.S. Soldiers and Marines in an operational setting from the corresponding Echelon III admissions data in the same theater of operation at the 95% confidence level. This ability was demonstrated through the statistical analysis of a data set captured by an active medical surveillance program by the 227th Medical Detachment (Epidemiology) during its deployment to Somalia.

However, caution must be taken when trying to generalize the proportions generated from Somalia data to another Theaters of Operation. It would be expected that Haiti, for example, would have similar proportions by category as Somalia because they have similar climates, vectors, diseases and to some degree, infrastructure problems. Bosnia, however, would be expected to have proportions that are different from Somalia because the medical threat is not the same.[29] This issue will be further discussed below.

Limitations of the Study

There are several important limitations of this thesis that any user of these estimation tools needs to understand. The first limitation concerns this database, which was passively acquired for use in this thesis. This database was not specifically designed

or collected for use in the manner that it was utilized; yet it fulfilled the needs for this data analysis. Diagnosis category had to be determined for 199 of the 809 records from the raw database. This was usually done from the discharge diagnosis, but for 84 records, it had to be done from an admission diagnosis. This hole in my data is attributed to the change in responsibility for medical surveillance from the 227th Medical Detachment to a subsequent epidemiology team that occurred at the end of week nine. Additionally, as the 227th began retrograde operations for redeployment back to CONUS, the diagnostic laboratory confirmation slips were not included into the database as a result of processing time from the diagnostic laboratory to the epidemiology team. As a result of having to determine discharge diagnosis seven years after the fact and not having the actual medical record of the patient concerned, there is the possibility of misclassification or disagreement of classification from the author of the database even though the categorical criteria was available.

The second is these hospitalizations to outpatient visit proportions were empirically derived from Somalia, a country with numerous endemic enteric and arboviral diseases. The data was taken during a nine-week period of time when Somalia was experiencing a dry season. As such, proportions may be different for the same hospitalization to outpatient visits during a corresponding wet season in the same country. A better designed study would have had a longer reporting period of the same parameters to determine if there were any seasonal fluctuations in these proportions. Additionally, a deployment to a different country, such as Bosina-Herzogovina or Kosovo, would quite

possibly experience different hospitalization to outpatient visit proportions do to vastly different health threats.

Third, this thesis does not consider all military personnel; it is limited to the United States Army, United States Marine Corps and the United States Navy personnel who served ashore. The United States Air Force personnel were specifically excluded for two reasons. The most important was their medical threat was vastly different to other military personnel due to their rotational policies out of Somalia into Kenya or out of theater. The second reason was their total numbers in Somalia (restricted to Mogadishu and Kissmayo) were so small that their numbers were insignificant to the total force and unstable to examine over the period of time for which data was available.

The perfect database for this study would have been actively acquired by the author, and designed from the outset to meet specific needs of a designed study. It would have lasted the entire length of the operation, had 100 percent capture of all outpatient visits and hospitalizations, and would have had the same person doing all diagnosis classifications.

Future Studies

This concept has future potential in research in homeland defense concerning weapons of mass destruction, specifically in the use of detecting the use of a biological warfare agent, once a firm understanding of hospitalization rates for a given exposure are understood. Additionally, this study should be done again with data from other Theaters

of Operation or even in the same Theater of Operation with data from different times of the year to examine proportional rates under various medical threat conditions.

APPENDICES

Appendix A. Disease Surveillance Categories for Somalia[30]

DISEASE SURVEILLANCE CATEGORIES

NOTE: ONLY THE FIRST VISIT FOR A NEW COMPLAINT SHOULD BE COUNTED. FOLLOWUPS SHOULD NOT BE COUNTED.

a. HEAT INJURIES (HTI): Any systemic heat related symptoms requiring treatment. Includes dehydration, heat cramps, heat exhaustion, heat stroke. Does not include sunburn.

b. Diarrhea/GI (GI): Focuses on INFECTIOUS CAUSES of symptoms. Includes diarrhea, gastroenteritis, dysentery, food poisoning, abdominal pain, appenditicitis, nausea/vomiting without other cause, intestinal parasites. Does not include GI bleeding, hemorrhoids, ulcers or other NON-INFECTIOUS diagnoses.

c. DEMATOLOGIC ILLNESSES (DER): All skin conditions presenting for medical evaluation. Includes fungal or bacterial infections, cellulitis, heat rash, blisters, dermatitis caused by insect bites.

d. RESPIRATORY ILLNESSES (RES): All upper and lower respiratory complaints. Includes URI, pharyngitis, rhinitis, allergic rhinitis, bronchitis, pneumonia, cough, bronchospasm, wheezing, asthma, and any other allergic or infectious respiratory complaint. Also includes secondary complications of respiratory symptoms, such as otitis media and sinusitis.

e. ORTHOPEDIC/ INJURIES (INJ): All musculoskeletal and soft-tissue complaints. Includes fractures, sprains, lacerations, abrasions, contusions, dislocations, muscle pulls, or other acute injuries (except eye injury). Also includes chronic musculoskeletal conditions such as chondromalacia, tendonitis, bursitis, back pain, neck pain, etc. Includes battle, non-battle occupational, recreational incidents. Specifically includes head injury.

f. ANIMAL BITES (BIT): All bites caused by animals. Does not include insect bites.

g. OPTHALMIC ILLNESSES/INJURIES (EYE): Conjunctivitis, eye infections or irritations, corneal abrasions, foreign bodies, solar injury, laser injury, trauma.

h. MEDICAL ILLNESSES (MED): Cardiac-related problems such as chest pain, hypertension; neurological problems such as headaches, convulsions, syncopal episodes; allergic reactions including systemic reactions to venomous bites/stings; hepatitis; urogenital illnesses not associated with sexually transmitted disease; internal conditions not related to trauma (e.g. appendicitis).

i. UNEXPLAINED FEVER (FEV): Temperature of 101 or greater for 24 hours without clear-cur etiology. This category is an initial screening method for malaria, dengue fever, chikungunya fever, or other unusual tropical infections.

j. SEXUALLY TRANSMITTED DISEASE (STD): All STDs. Includes gonorrhea, syphilis, chlamydia, genital herpes, pelvic inflammatory disease, venereal warts/chancres.

K. DENTAL (DEN): Dental injury, disease, or condition requiring care by a dentist.

l. PSYCHIATRIC ILLNESSES (PSY): Depression, situational reactions, anxiety, neuroses, psychotic reactions, suicide attempts, or behavioral reaction to medication.

m. SUBSTANCE ABUSE (ABU): Abuse of alcohol, illegal drugs including marijuana, khat, pharmaceuticals (prescribed or unprescribed), or other substances.

n. MISCELLANEOUS (MISC): All other complaints presenting to a sick call not fitting above categories.

Appendix B. Number of Outpatient Visits by Week and Category for Army, Navy, and Marines Assigned Ashore to US Forces Somalia during the timeframe of 10 January 1993 through 13 March 1993.

Week	Diarrhea/GI	Dermatological	Respiratory	Ortho/Injury	Unexplained Feve	Heat Injury	Animal Bites	Ophthalmic	Medical Illness	Sex Trans Dis	Dental	Psychiatric	Substance Abuse	Miscellaneous	Total OPVs	Total Population
One	109	370	160	386	67	42	6	78	109	7	99	25	0	229	1,687	15,047
Two	145	456	190	456	49	23	2	102	130	7	170	9	1	285	2,025	16,368
Three	126	350	153	426	28	24	9	79	145	8	103	7	0	300	1,758	15,311
Four	116	323	108	395	38	24	7	55	217	2	41	3	0	231	1,560	15,260
Five	121	250	124	408	21	33	20	74	192	4	118	2	0	184	1,594	14,792
Six	115	219	90	325	6	18	10	48	102	5	22	9	0	108	1,146	12,102
Seven	60	184	57	276	13	7	5	50	90	3	12	1	0	71	829	9,939
Eight	31	130	57	228	9	5	6	29	71	2	28	3	0	91	690	8,271
Nine	90	172	68	246	12	4	6	37	119	4	37	2	1	134	932	8,654
Totals	913	2,454	1,007	3,146	243	180	71	552	1,175	42	630	61	2	1,633	12,221	115,744

Appendix C. Number of Hospital Admissions by Week and Category for Army, Navy, and Marines Assigned Ashore to US Forces Somalia during the timeframe of 10 January 1993 through 13 March 1993.

Week	Diarrhea	Dermatologic	Respiratory	Orthopedic/Injury	Unexplained Fever	Heat Injury	Animal Bites	Ophthalmic	Medical Illness	Sex Trans Dis	Dental	Psychiatric	Substance Abuse	Miscellaneous	Total Admissions	Total Population
One	2	0	2	11	8	2	0	0	9	0	1	2	0	5	42	15,047
Two	13	1	4	18	40	2	3	4	17	0	0	3	0	0	105	16,368
Three	14	5	8	23	37	1	0	3	29	1	1	1	0	0	123	15,311
Four	13	7	5	19	26	0	1	1	21	0	0	1	0	0	94	15,260
Five	1	1	1	24	28	0	0	0	21	0	1	0	0	0	77	14,792
Six	9	2	1	23	15	0	0	3	15	0	0	1	0	0	69	12,102
Seven	2	4	4	14	11	0	0	2	19	0	0	1	0	0	57	9,939
Eight	1	3	5	13	10	0	0	1	19	0	0	3	0	0	55	8,271
Nine	3	1	0	18	19	1	0	0	22	0	0	1	0	0	65	8,654
Totals	58	24	30	163	194	6	4	14	172	1	3	13	0	5	687	115,744

Appendix D. Application of DNBI Estimation Tool.

The following are examples of applying the methodology proposed within this thesis to estimate DNBI weekly visits at Echelon I and II.

Example 1 – Your division is deployed to the Eastern Horn of Africa to support United Nations peacekeepers in Eritrea. The division's 15,000 soldiers have been in theater for six weeks and some have been admitted to a supporting Combat Support Hospital (Echelon III). From a planning meeting, you learn that the division's 1st Brigade Combat Team, composed of 4,300 soldiers, will be used in an offensive in the immediate future. From an active medical surveillance program, you know that 1st Brigade had 62 Echelon III admissions for diarrhea, last week. You want to know how much DNBI at is at Echelon I and II, to determine if the Division Surgeon should recommend using a different brigade be used for the upcoming offensive action due to health reasons. You use the equation previously introduced in the main body of this thesis as Equation 1 to compute the C.I. for the denominator to estimate DNBI at Echelon I and II.

$$\frac{\text{Echelon III admissions for diarrhea}}{\text{Estimation Proportion Value by Type (diarrhea)}} = \text{Predicted DNBI Echelon I and II OPVs}$$

$$\frac{62 \text{ total admissions for diarrhea}}{0.057 \text{ est. factor for diarrhea}} = 1{,}088 \text{ Echelon I and II OPVs (Median)}$$

Ninety five percent confidence intervals can be computed by substituting the denominator (0.057) with the estimators 0.027 and 0.087 to yield the values 2,296 and

713 estimated Echelon I and II outpatient visits, as demonstrated in the next two calculations.

$$\frac{\text{62 total admissions for diarrhea}}{\text{0.027 est. factor for diarrhea}} = \text{2,296 Level I and II Outpatient Visits (High)}$$

$$\frac{\text{62 total admissions for diarrhea}}{\text{0.087 est. factor for diarrhea}} = \text{713 Level I and II Outpatient Visits (Low)}$$

This would allow the medical planner to estimate that 1st Brigade had 1088 patient visits for diarrhea with a range of 713 to 2,296 patient visits with a 95 percent confidence interval. As a result, we could recommend to the division commander that either reinforce 1st Brigade with additional troops or use either 2nd or 3rd Brigade, assuming that these two Brigades are healthy, in the upcoming offensive actions, because 1st Brigade could be near combat ineffective due to DNBI, if last week's data is predictive of this week's data.

Example 2 - Your division is deployed to Haiti to support United Nations peacekeepers. The division's 15,000 soldiers have been in the country for three weeks and some have been admitted to a supporting Combat Support Hospital (Echelon III). Last week the division had 98 Echelon III admissions of all types. You have been asked by the division surgeon to assist him in preparing a Command Health Report to be given to the Commanding General of the division. From you active health surveillance program, you do the following calculation.

$$\frac{\text{Echelon III admissions}}{\text{Estimation Proportion Value by Type}} = \text{Predicted DNBI Echelon I and II OPVs}$$

$$\frac{\text{98 total admissions}}{\text{0.059 est. factor for total morbidity values}} = \text{1,661 Level I and II OPVs (Median)}$$

$$\frac{\text{98 total admissions}}{\text{0.047 est. factor for total morbidity values}} = \text{2,085 Level I and II OPVs (High)}$$

$$\frac{\text{98 total admissions}}{\text{0.071 est. factor for total morbidity values}} = \text{1,380 Level I and II OPVs (Low)}$$

You estimate for the report that approximately 1,661 outpatient visits, of all kinds, occurred using the median estimator of 0.059 as the denominator. You also estimate a range of 1,380 to 2,085 visits within the division last week with a 95 percent confidence interval using values calculated with Equation 1 to determine the denominator values of 0.071 and 0.047. Keep in mind that the Echelon III numerator and the estimation factor in the denominator must correspond by type (total admissions to est. factor for total morbidity; total orthopedic / injury to est. factor for orthopedic / injury). You would further inform the Division Medical Supply Officer (DMSO) of your estimate so they can plan for medical supplies accordingly.

Appendix E. Graphs of Echelon I and II outpatient visits, Echelon III admissions, and Proportions of hospitalizations to outpatient visits by diagnostic category and week for US Army, Navy and Marines assigned ashore during Operation Restore Hope, starting 10 January 1993 – 16 March 1993.

Figure E-1. Weekly Diarrheal Echelon I and II Outpatient Visits of U.S. Army, Navy, and Marine Corps Personnel Assigned Ashore to U.S. Forces Somalia During Operation Restore Hope, Beginning 10 January 1993.

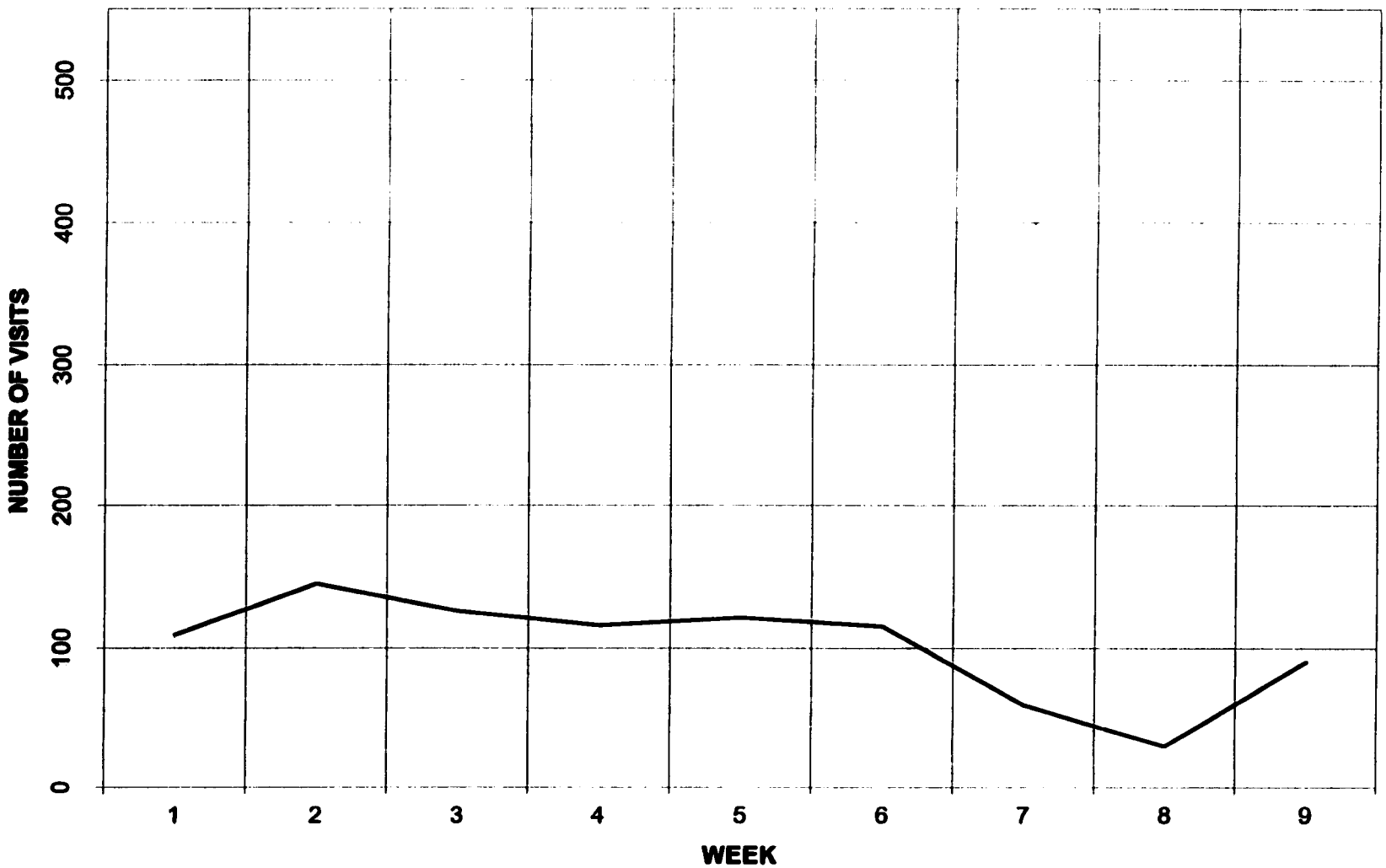


Figure E-2. Weekly Dermatological Echelon I and II Outpatient Visits of U.S. Army, Navy, and Marine Corps Personnel Assigned Ashore to U.S. Forces Somalia During Operation Restore Hope, Beginning 10 January 1993.

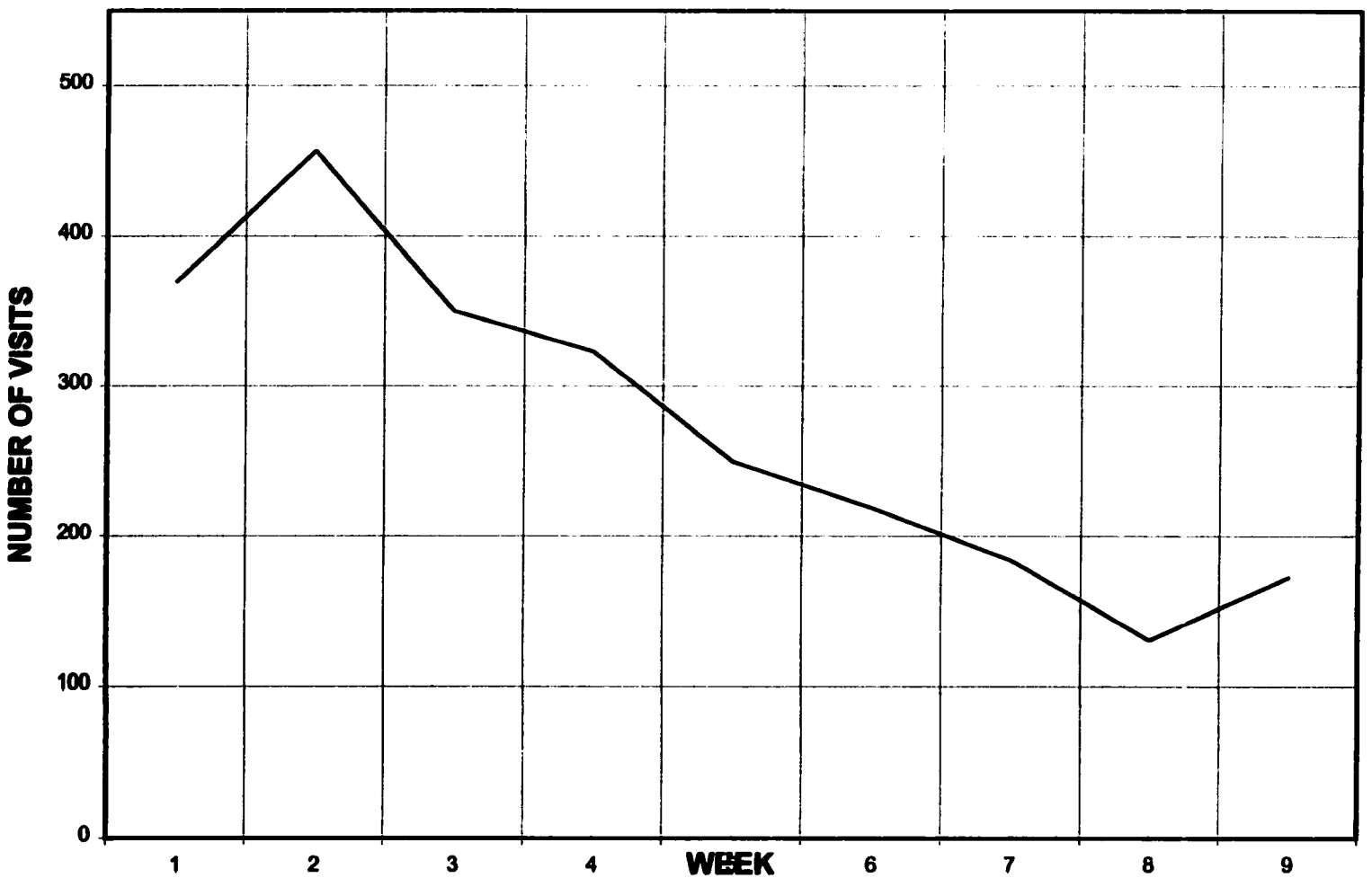


Figure E-3. Weekly Respiratory Echelon I and II Outpatient Visits of U.S. Army, Navy, and Marine Corps Personnel Assigned Ashore to U.S. Forces Somalia During Operation Restore Hope, Beginning 10 January 1993.

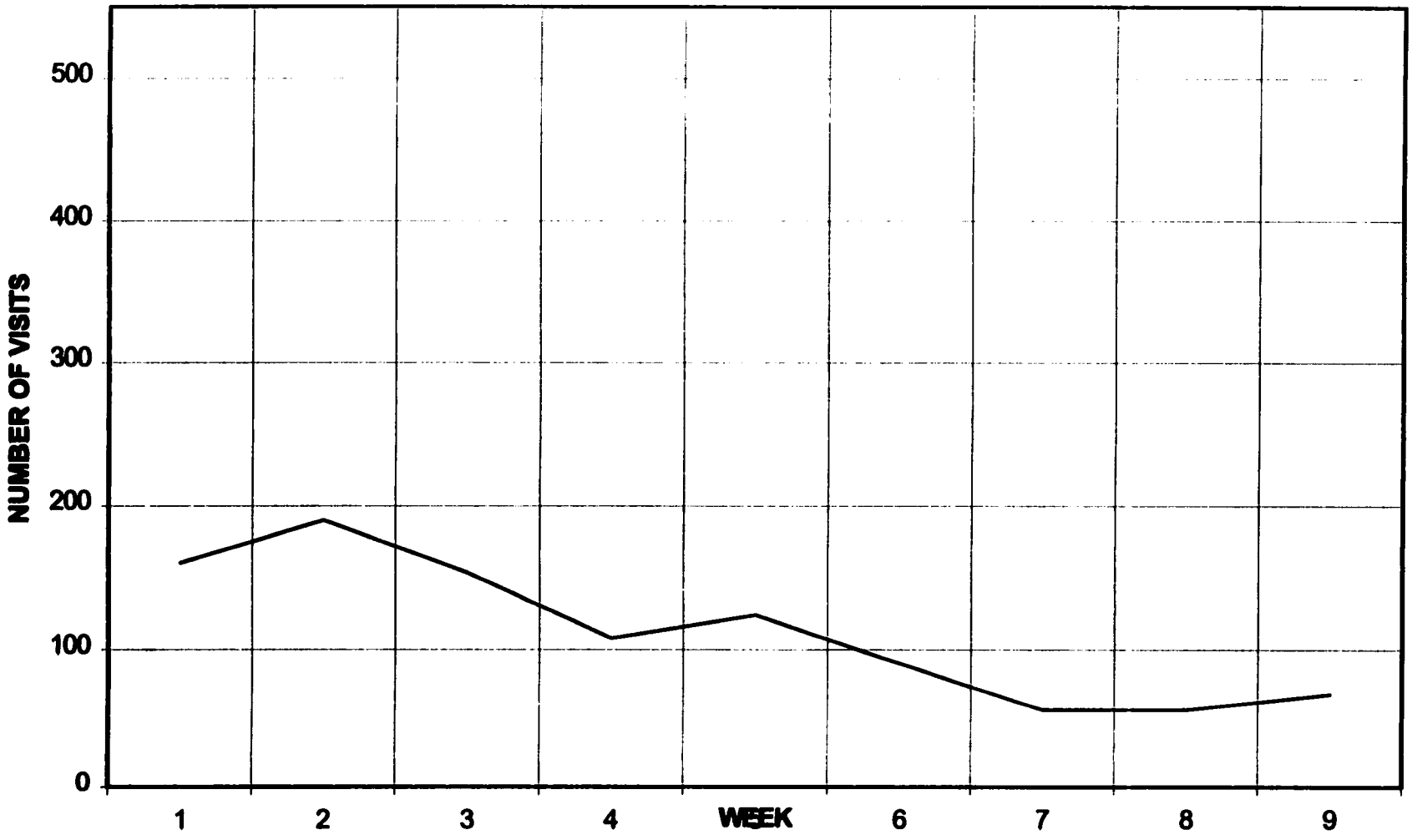


Figure E-4. Weekly Orthopedic/Injury Echelon I and II Outpatient Visits of U.S. Army, Navy, and Marine Corps Personnel Assigned Ashore to U.S. Forces Somalia During Operation Restore Hope, Beginning 10 January 1993.

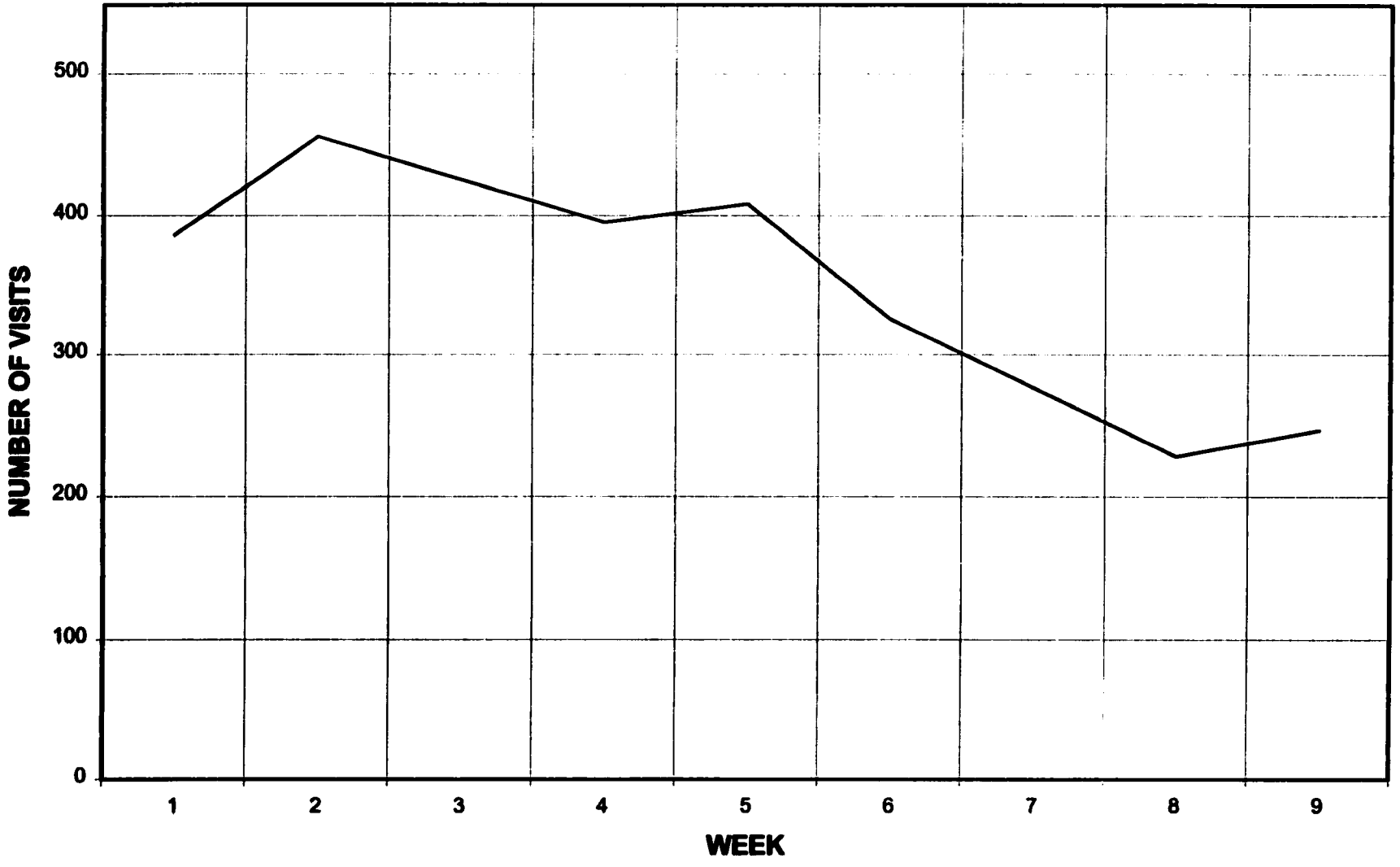


Figure E-5. Weekly Unexplained Fever Echelon I and II Outpatient Visits of U.S. Army, Navy, and Marine Corps Personnel Assigned Ashore to U.S. Forces Somalia During Operation Restore Hope, Beginning 10 January 1993.

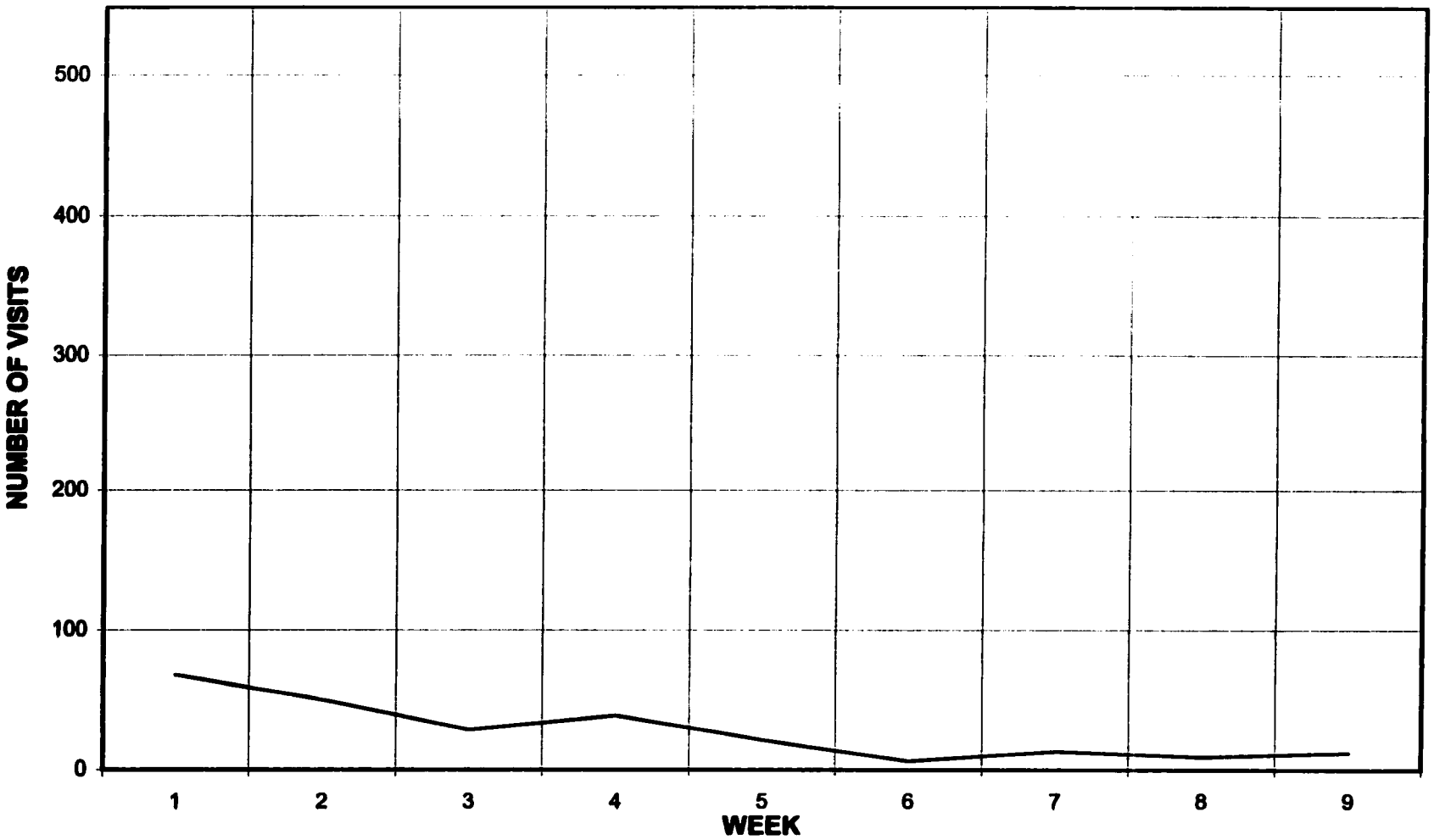


Figure E-6. Weekly Total of the Fourteen Disease Survielance Categories for Echelon I and II Outpatient Visits of U.S. Army, Navy, and Marine Corps Personnel Assigned Ashore to U.S. Forces Somalia During Operation Restore Hope, Beginning 10 January 1993.

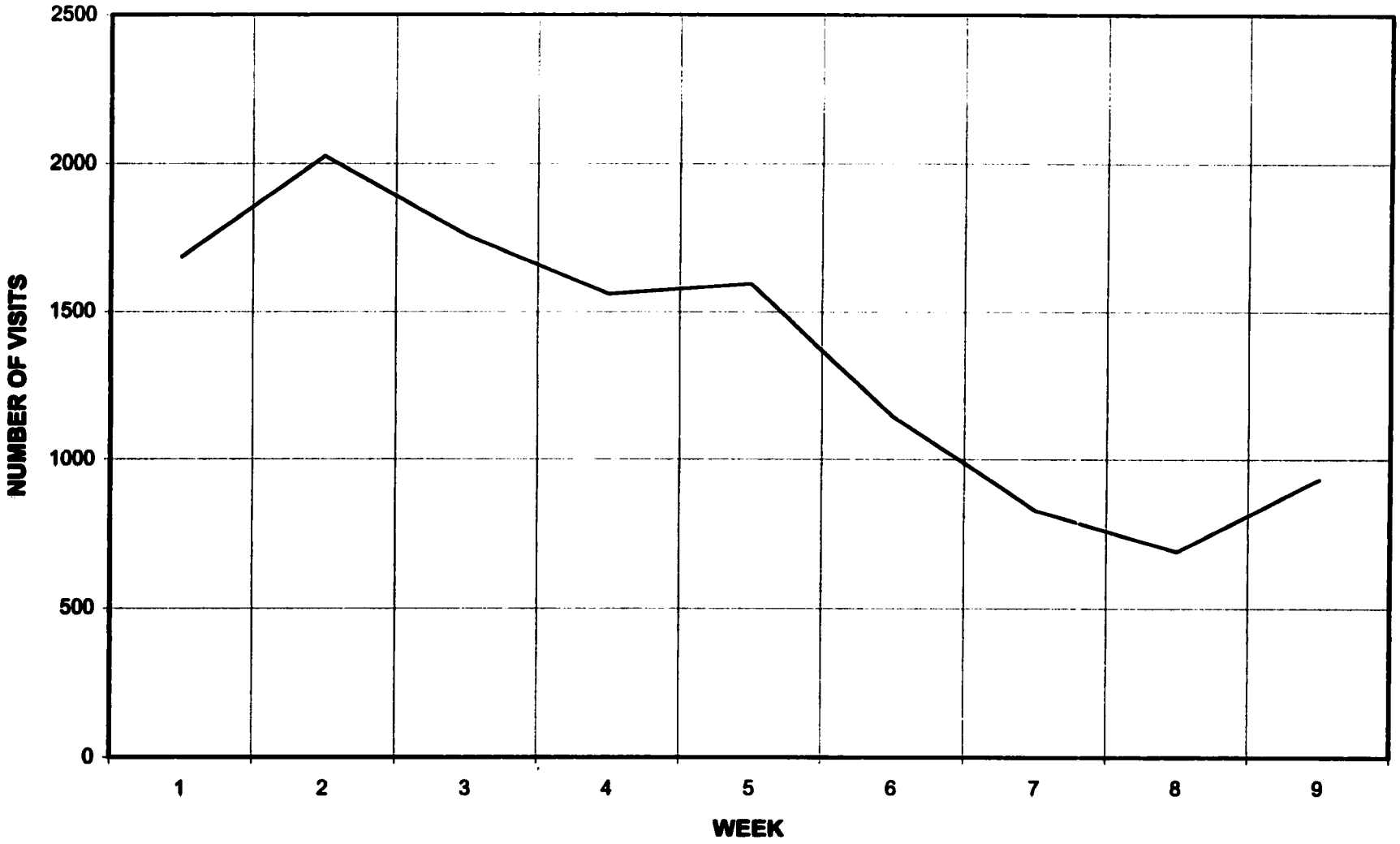


Figure E-7. Weekly Diarrheal Echelon III Hospital Admissions of U.S. Army, Navy, and Marine Corps Personnel Assigned Ashore to U.S. Forces Somalia During Operation Restore Hope, Beginning 10 January 1993.

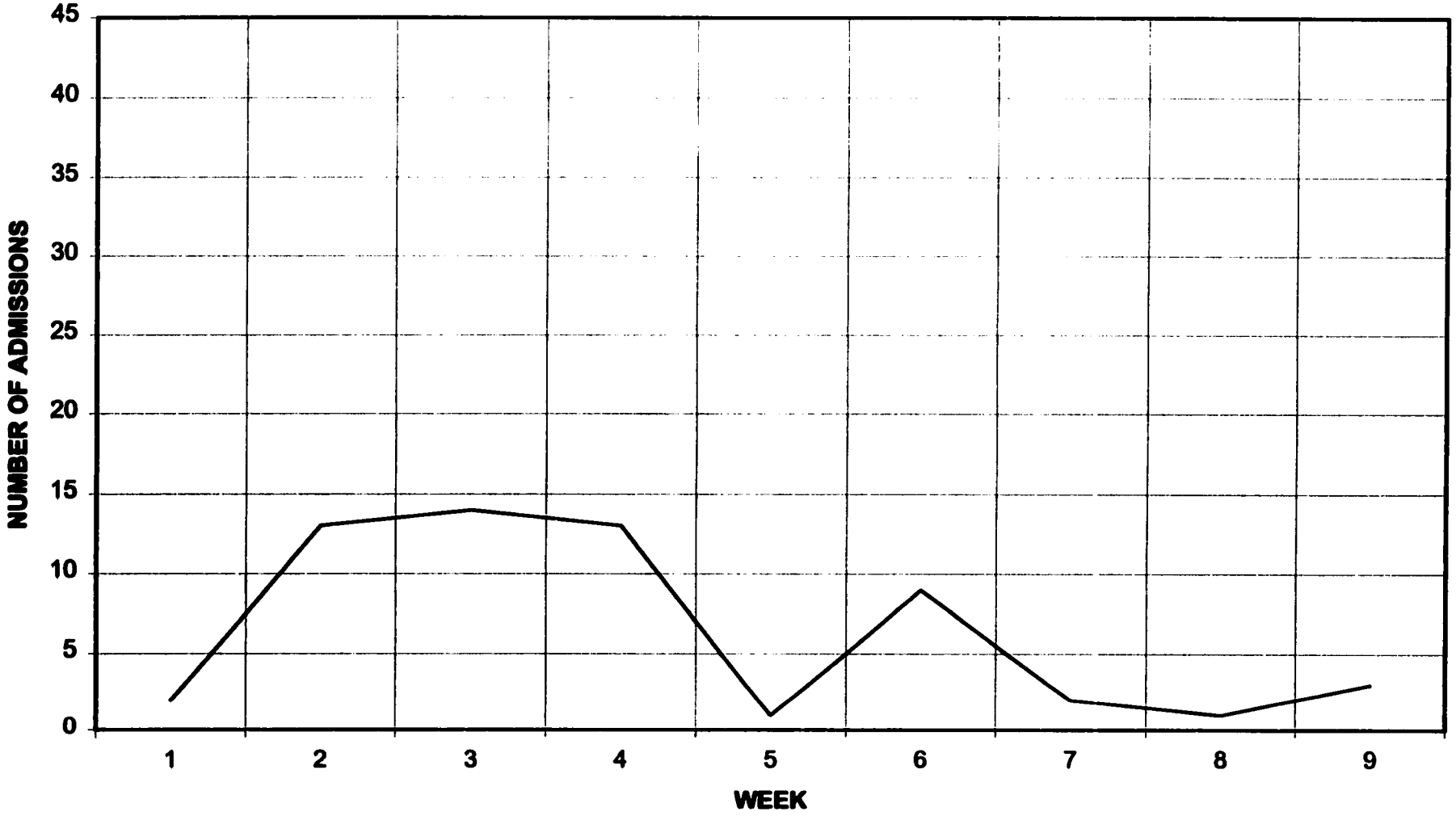
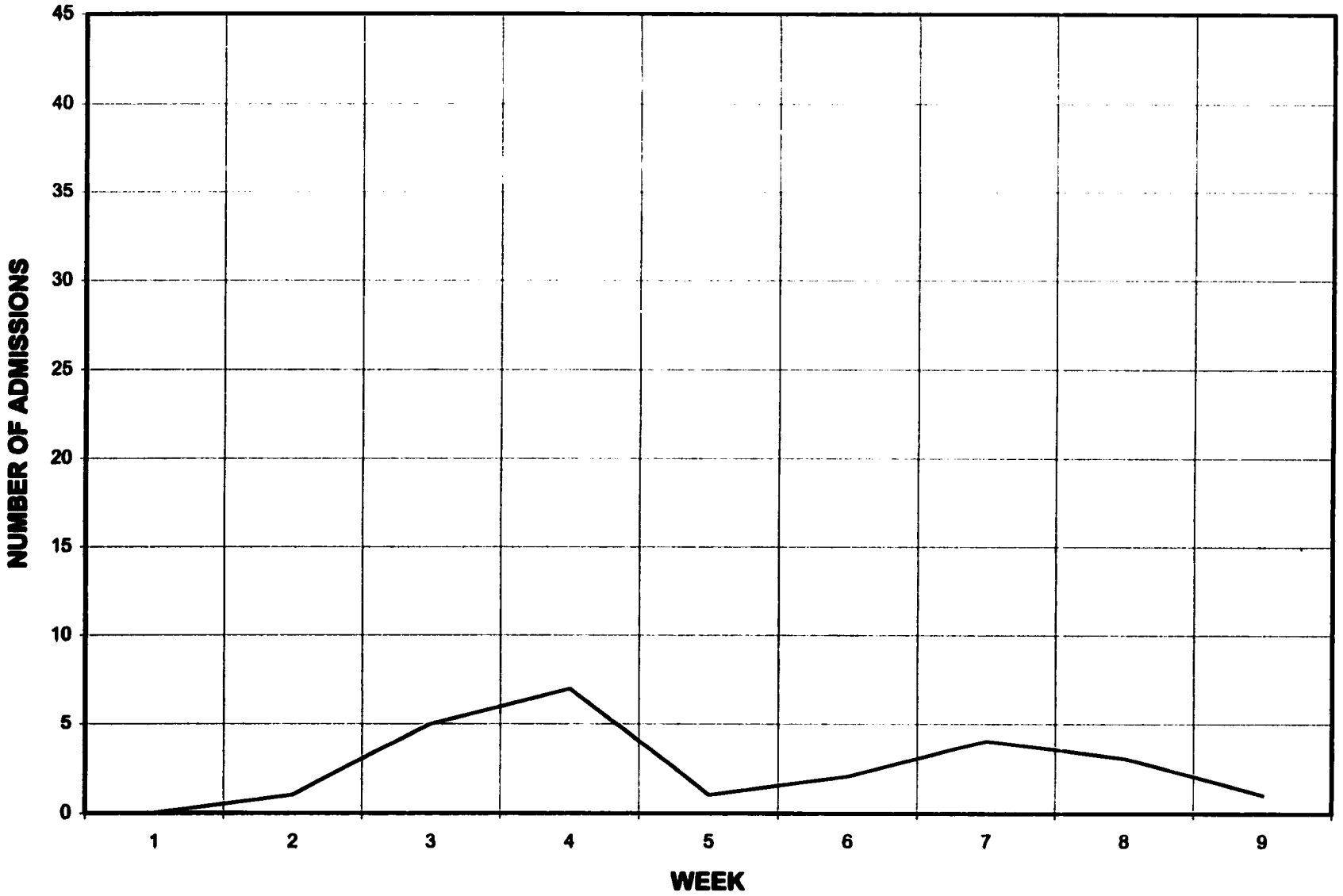


Figure E-8. Weekly Dermatological Echelon III Hospital Admissions of U.S. Army, Navy, and Marine Corps Personnel Assigned Ashore to U.S. Forces Somalia During Operation Restore Hope, Beginning 10 January 1993.



Figue E-9. Weekly Respiratory Echelon III Hospital Admissions of U.S. Army, Navy, and Marine Corps Personnel Assigned Ashore to U.S. Forces Somalia During Operation Restore Hope, Beginning 10 January 1993.

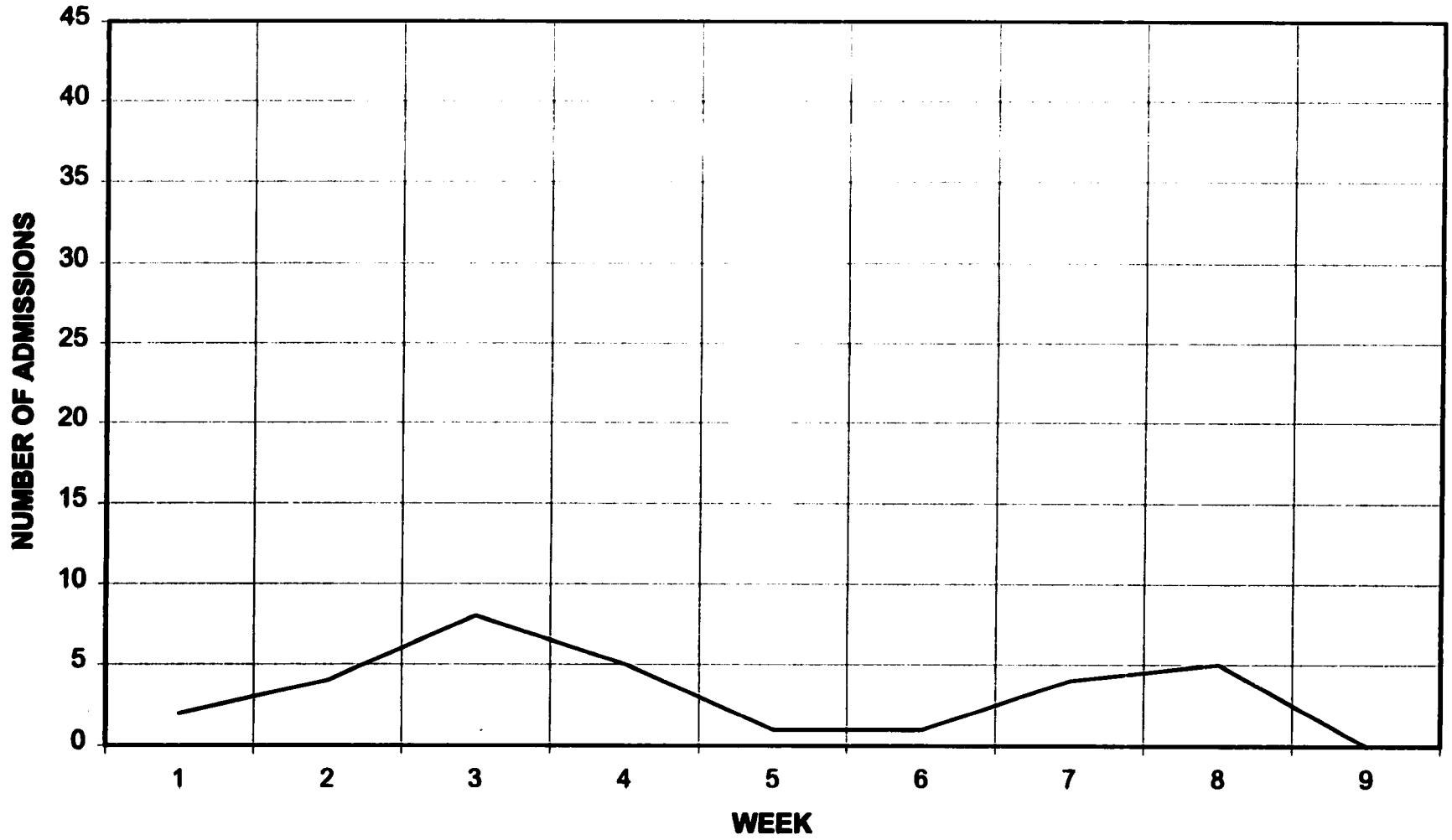


Figure E-10. Weekly Orthopedic/Injury Echelon III Hospital Admissions of U.S. Army, Navy, and Marine Corps Personnel Assigned Ashore to U.S. Forces Somalia During Operation Restore Hope, Beginning 10 January 1993.

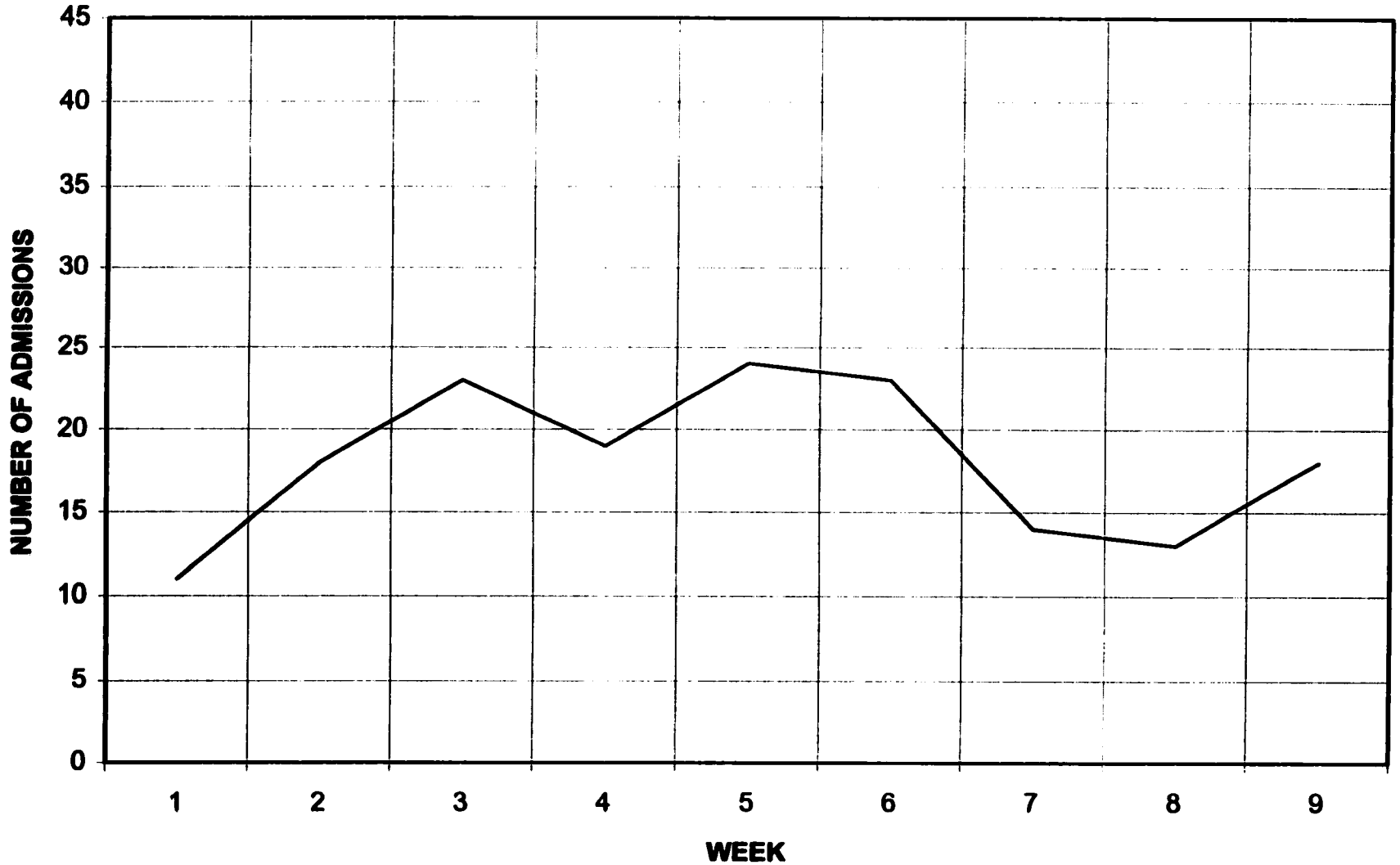


Figure E-11. Weekly Unexplained Fever Echelon III Hospital Admissions of U.S. Army, Navy, and Marine Corps Personnel Assigned Ashore to U.S. Forces Somalia During Operation Restore Hope, Beginning 10 January 1993.

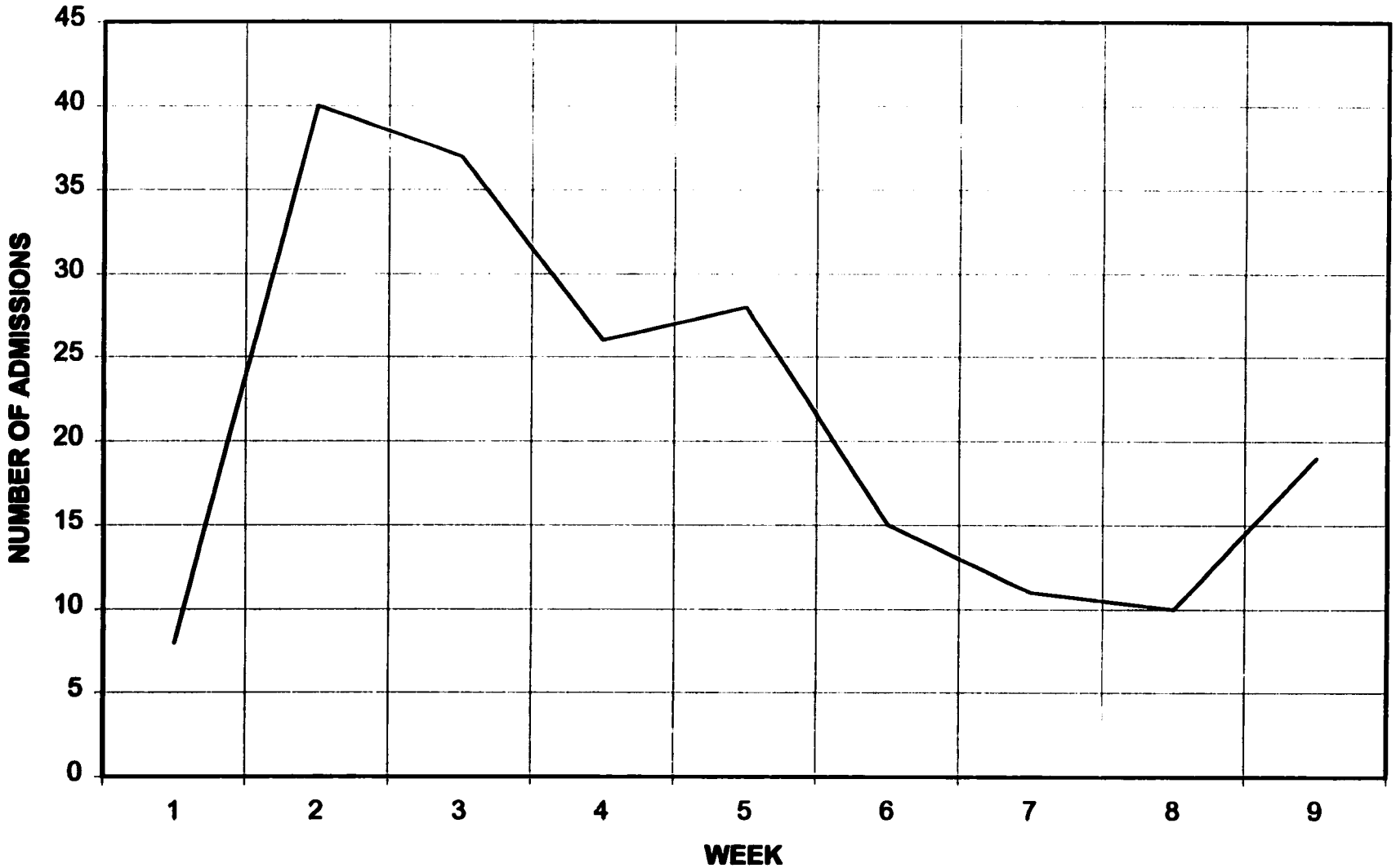


Figure E-12. Weekly Echelon III Hospital AdmissionTotal of the Fourteen Disease Survielance Categories for U.S. Army, Navy, and Marine Corps Personnel Assigned Ashore to U.S. Forces Somalia During Operation Restore Hope, Beginning 10 January 1993.

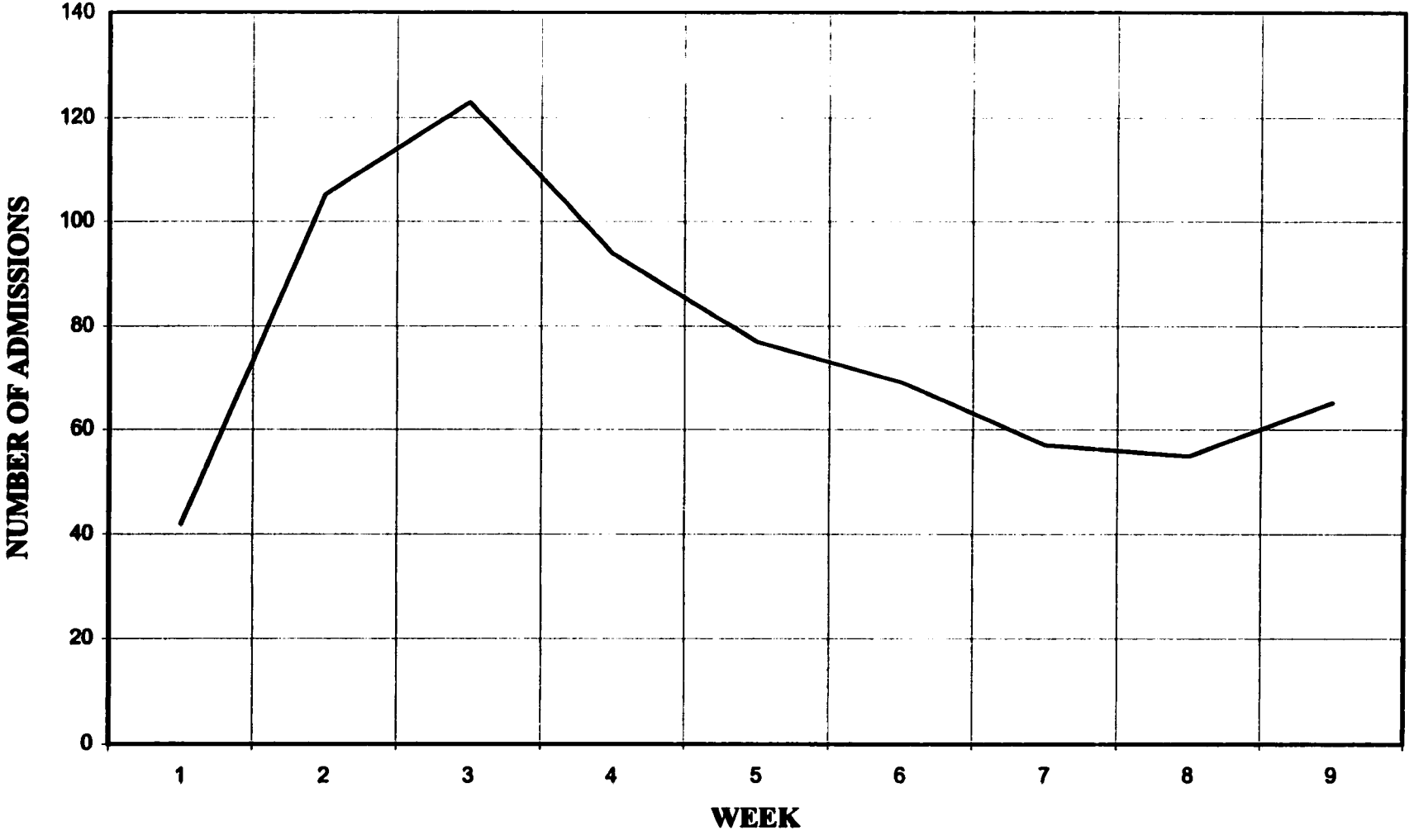


Figure E-13. Weekly Diarrheal Proportion of Hospital Admissions to Outpatient Visits for U.S. Army, Navy, and Marine Corps Personnel Assigned Ashore to U.S. Forces Somalia During Operation Restore Hope, Beginning 10 January 1993.

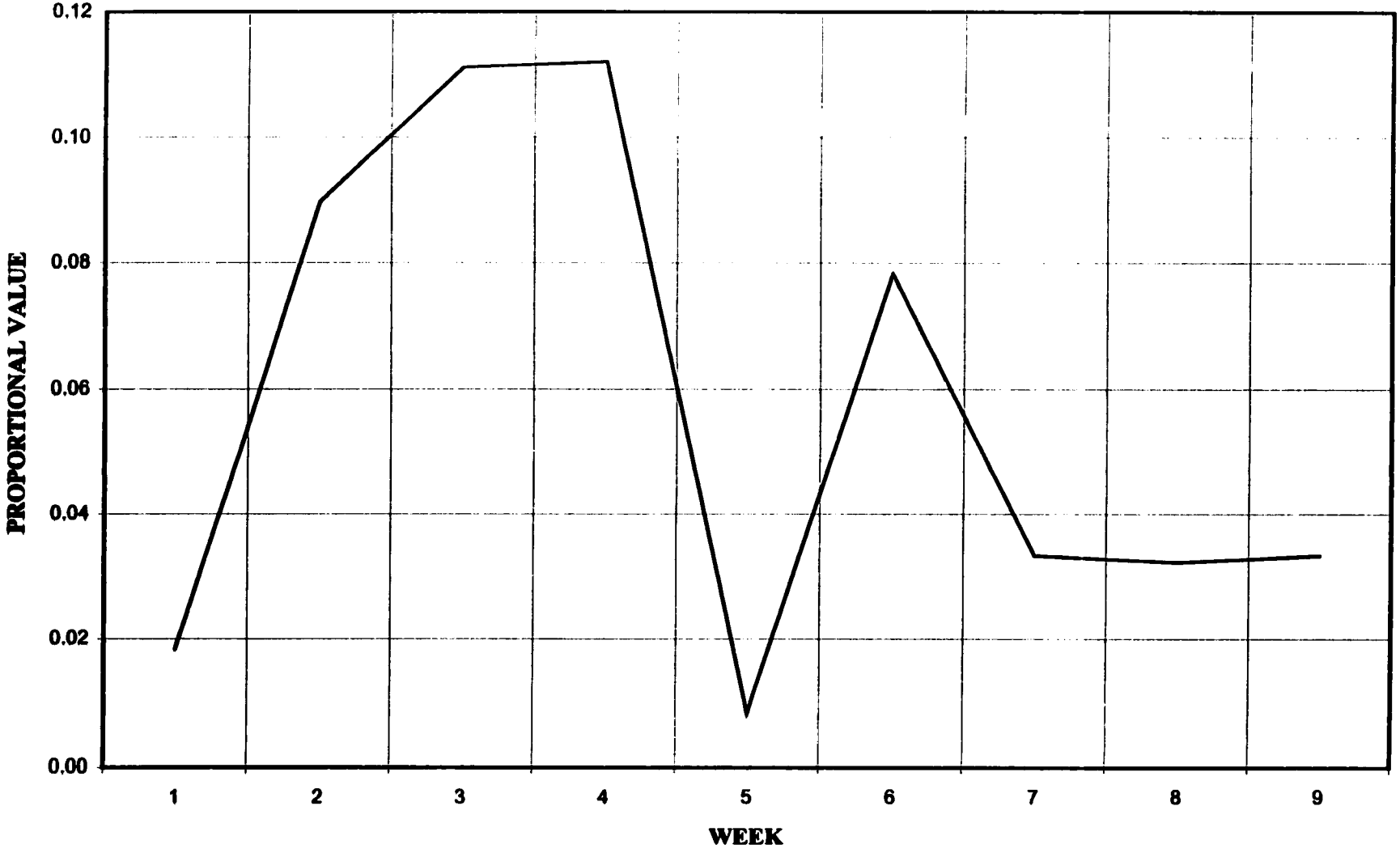


Figure E-14. Weekly Proportion of Dermatological Hospital Admissions to Outpatient Visits for U.S. Army, Navy, and Marine Corps Personnel Assigned Ashore to U.S. Forces Somalia During Operation Restore Hope, Beginning 10 January 1993.

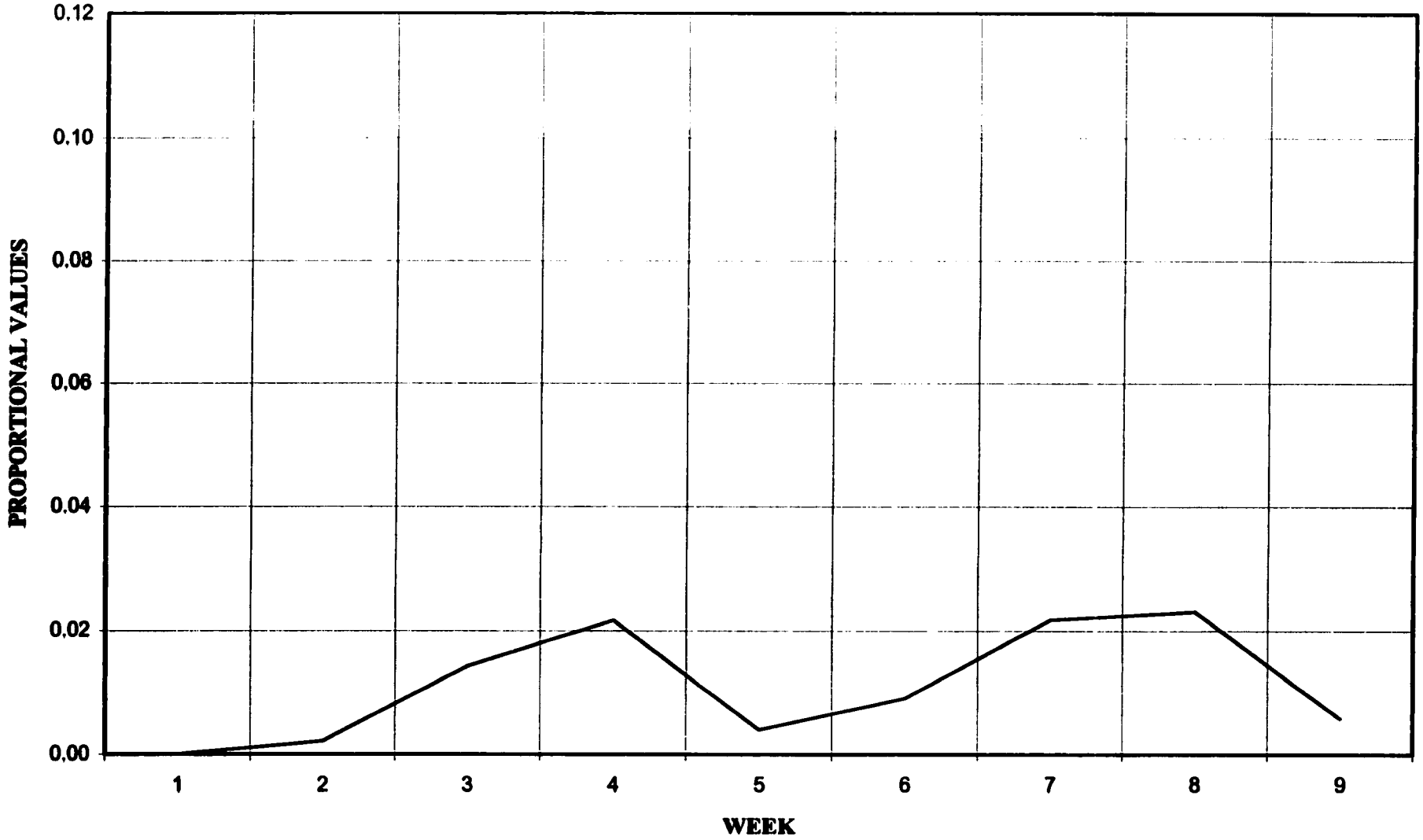


Figure E-15. Weekly Proportion of Respiratory Hospital Admissions to Outpatient Visits for U.S. Army, Navy, and Marine Corps Personnel Assigned Ashore to U.S. Forces Somalia During Operation Restore Hope, Beginning 10 January 1993.

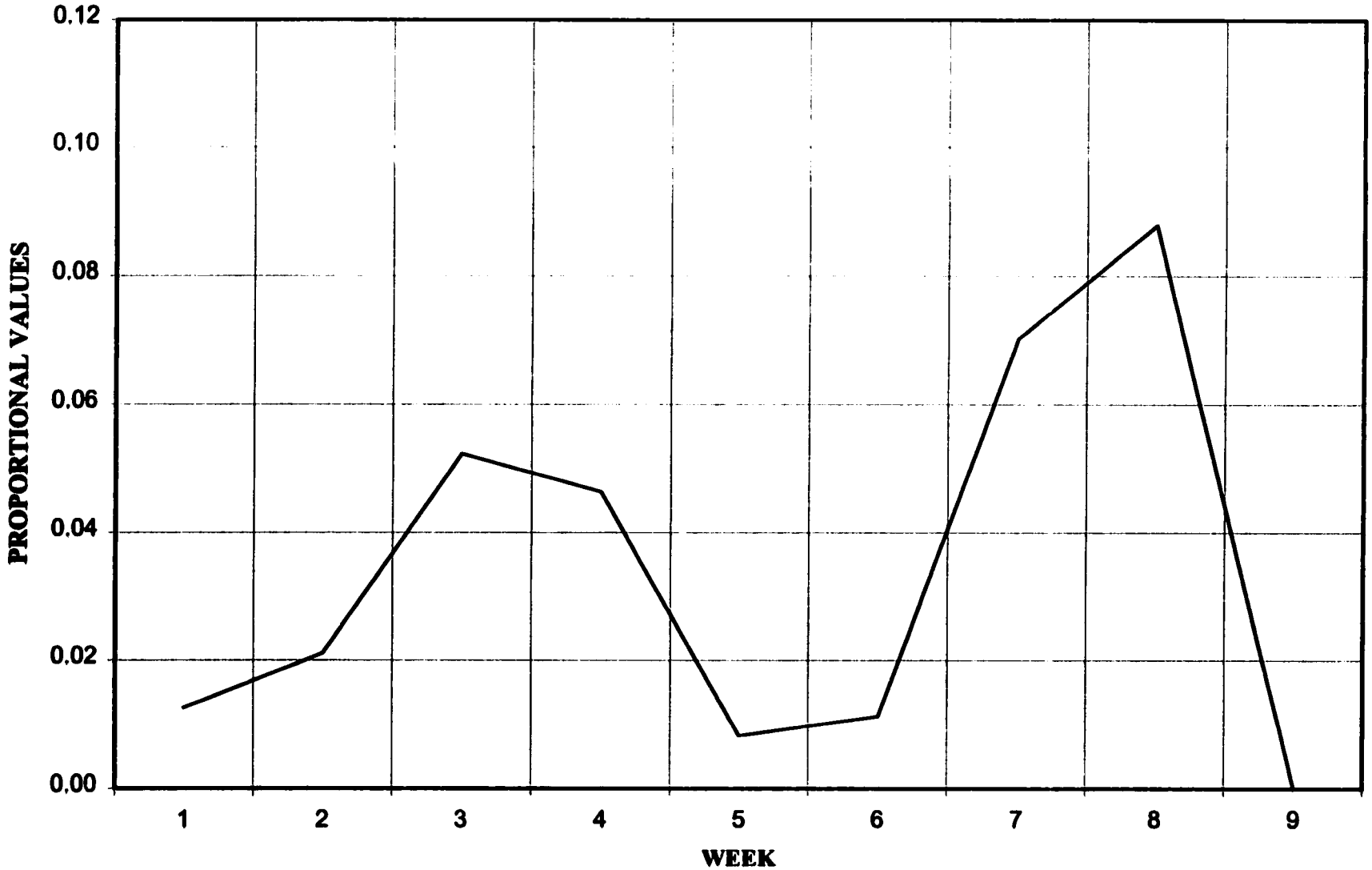


Figure E-16. Weekly Orthopedic/Injury Proportion of Hospital Admissions to Outpatient Visits for U.S. Army, Navy, and Marine Corps Personnel Assigned Ashore to U.S. Forces Somalia During Operation Restore Hope, Beginning 10 January 1993.

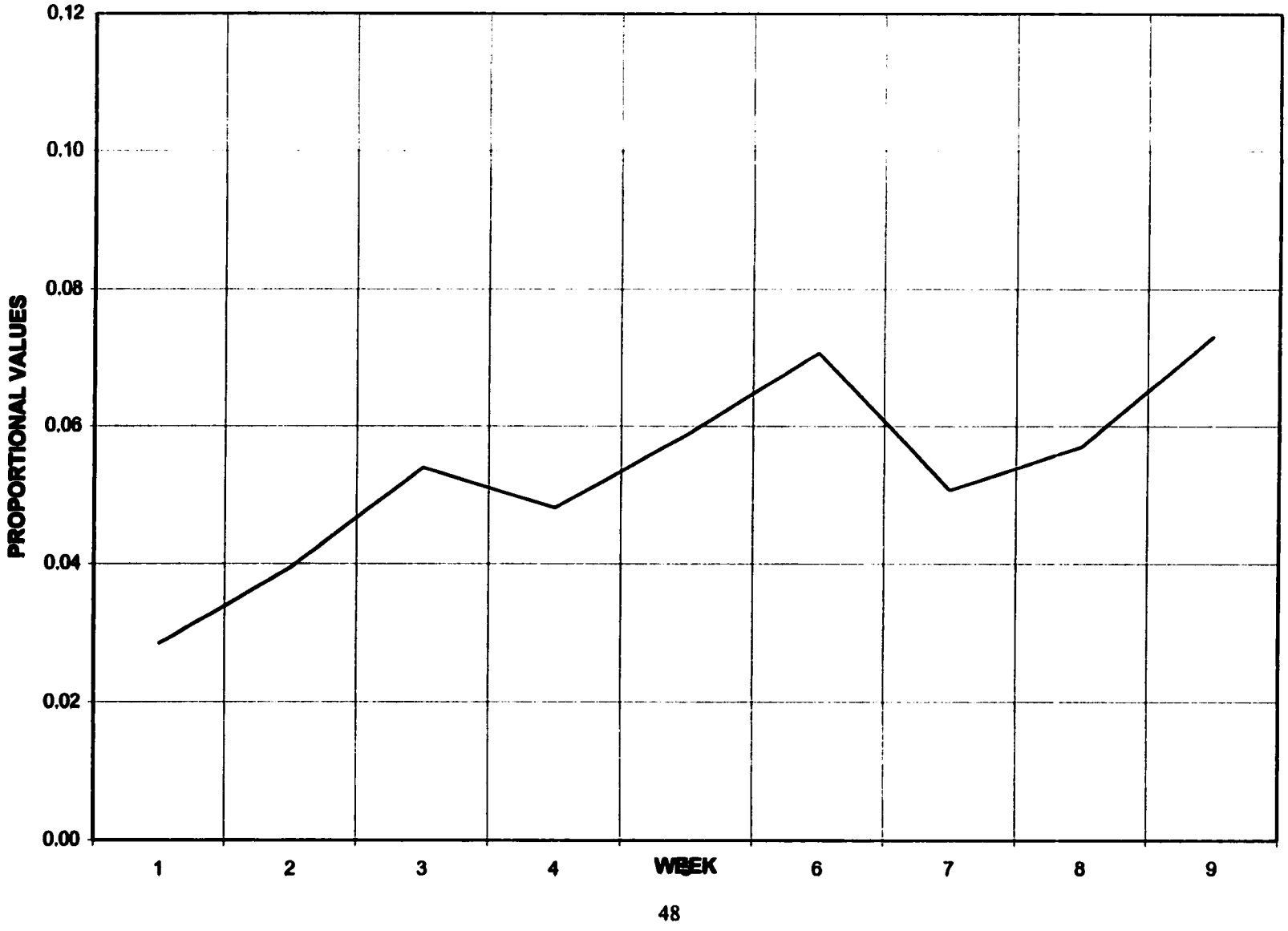


Figure E-17. Weekly Unexplained Fever Proportion of Hospital Admissions to Outpatient Visits for U.S. Army, Navy, and Marine Corps Personnel Assigned Ashore to U.S. Forces Somalia During Operation Restore Hope, Beginning 10 January 1993.

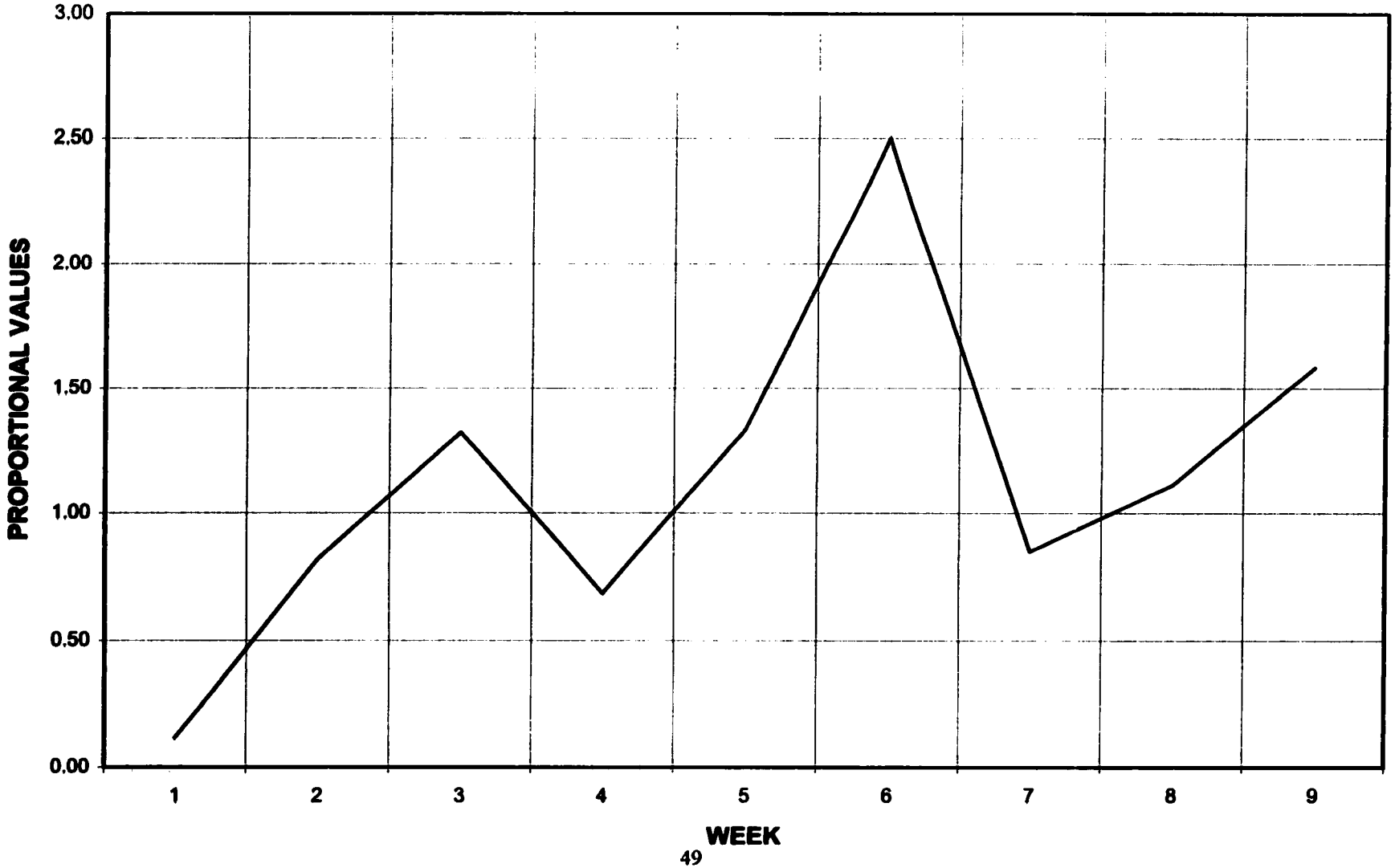
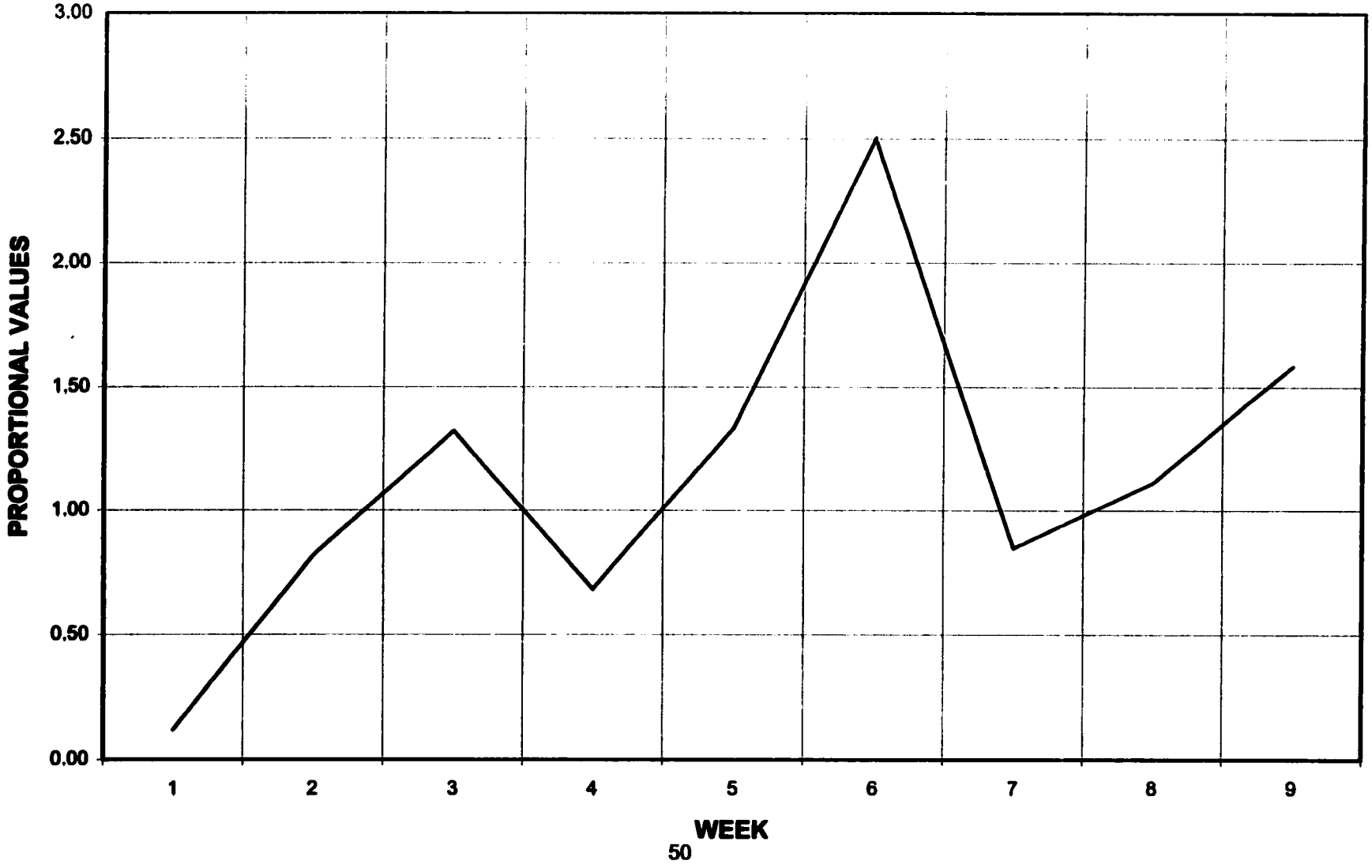


Figure E-17. Weekly Unexplained Fever Proportion of Hospital Admissions to Outpatient Visits for U.S. Army, Navy, and Marine Corps Personnel Assigned Ashore to U.S. Forces Somalia During Operation Restore Hope, Beginning 10 January 1993.



Glossary of Terms

Combined (Force): Between two or more forces or agencies of two or more allies. (When all allies or services are not involved, the participating nations and services shall be identified, e.g., Combined Navies.)[31]

Combat Support Hospital (CSH): This unit provides hospitalization for up to 296 patients. The hospital has eight wards providing intensive nursing care for up to 96 patients, seven wards providing intermediate nursing care for up to 140 patients, on ward providing neuropsychiatric (NP) care for up to 20 patients, and two wards providing minimal nursing care for up to 40 patients. (The 86th CSH deployed a 56-bed support slice)[32]

Disease and Non-battle Injury (DNBI): A person who is not a battle casualty but is lost to the organization by reason of disease or injury, including persons dying of disease or injury, by reason of being missing where the absence does not appear to be voluntary, or due to enemy action or to being interned.[33]

Health Service Support (HSS): All support services performed, provided, or arranged by the AMEDD to promote, improve, conserve, or restore the physical or mental health of supported personnel. These services include but are not limited to the medical battlefield operating system (BOS) of evacuation, hospitalization, medical logistics, area support, dental services, laboratory services, preventive medicine services, blood management, medical regulating, and mental health services.[34]

Joint (Force): A general term applied to a force composed of significant elements, assigned or attached, of two or more Military Departments, operating under a single commander authorized to exercise operational control.[35]

Echelon (Level) I Health Service Support (HSS): The first medical care a soldier receives is provided at this echelon and includes immediate life saving measures, DNBI prevention, combat stress control measures, casualty collection and evacuation to a supporting MTF. Echelon I HSS is provided by the medical platoon/section of combat and Combat Support (CS) battalions, by divisions, separate brigade and Armored Calvary Regiment (ACR) medical companies, by corps and echelons above corps area support medical companies (ASMCs), and by other corps and echelons above corps medical units.[36]

Echelon (Level) II Health Service Support: This echelon of care includes evacuating patients from Echelon I, providing care at clearing stations where wounds and general status of a patient are evaluated and, if necessary, prioritized for further evacuation. Medical services include dental, laboratory, x-ray, and patient holding for up to 72 hours for patients who can be returned to duty (RTD). Additionally, this is the lowest level where blood is found.[37]

Echelon (Level) III Health Service Support: This level of support expands the capabilities provided at Echelon II. Patients who are unable to tolerate and survive movement over long distances receive surgical care in hospitals a close to the division rear boundary as the tactical situation allows. Echelon III characterizes care provided by units such as a Mobile Army Surgical Hospital (MASH) or a CSH.[38]

Intelligence Preparation of the Battlespace (Battlefield) (IPB): An analytical methodology employed to reduce uncertainties concerning the enemy, environment, and terrain for all types of operations. Intelligence preparation of the battlespace builds an extensive database for each potential area in which a unit may be required to operate. The database is then analyzed in detail to determine the impact of the enemy, environment, and terrain on operations and presents it in graphic form.[39]

Medical Planner: Any AMEDD individual responsible for planning tactical or operational level HSS. The primary medical planners are those individuals who are in the defined career area of concentration (AOC) of Health Services Plans, Operations, Intelligence, Security, and Training Officer (70H). However, other occupational codes, both officer and enlisted have substantive input on assessing the medical threat. Currently, there are 256 officers in the US Army with the career AOC of 70H in various grades from O-3 to O-6 (Captain to Colonel).[40]

Medical Threat: All potential or continuing threats posed by enemy forces and environmental factors that could possibly adversely affect the health of the command and the combat effectiveness of friendly forces.[41] The medical threat includes all enemy actions that could cause harm to friendly forces from both conventional and weapons of mass destruction. The medical threat also includes all environmental threats that may reduce combat effectiveness of friendly forces. Environmental threats include climate, weather, endemic disease, poisonous flora and fauna, zoological threats, and other industrial and environmental issues. The medical threat also includes the effects of prolonged combat and combat or deployment stress.[42]

Morbidity rates: A description of the frequency of illness within a population.[43]

MTF: Medical Treatment Facility

Outpatient Visit: Visits by patients to a healthcare provider that do not require admission to a hospital (Echelon III) facility.

TO: Theater of Operations[44]

Walking Wounded: Troops who have some level of morbidity, making them have less than an optimum level of health, which may impact on their individual ability to accomplish the military mission before them. These are troops who are not hospital (Echelon III) admissions, but are return to duty (RTD) or receive health care from an Echelon I or II health care facility.

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